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# Fishery Technology, 2001, Vol 38(2)

## CONTENTS


| | Page |
|---|---|
| Cold-anaesthetization and Live Transportation of Penaeid shrimps<br>K.R. Salin & K. Jayasree Vadhyar | 71 |
| Comparative Fishing Efficiency of Lobster Traps<br>A. Balasubramanian, E. Kathavarayan & N. Neethiselvan | 77 |
| Relative Fuel Consumption and Effective Fishing Time of Small-scale Mechanised Gillnetters, off Cochin<br>A.V. Shibu & M. Shahul Hameed | 81 |
| Optimization of Mesh Size of Gill Nets for *Sardinella gibbosa* (Bleeker)<br>N. Neethiselvan, T. Vaitheeswaran & D. Jude | 84 |
| Changes During Frying of Mackerel at Different Temperatures<br>B.K. Chand, K.C Dora, S. Sarkar & M.M. Maragal | 87 |
| Biogenic Amines in Fresh, Canned and Salt-dried Fishery Products of India<br>R. Jeya Shakila & T.S. Vasundhara | 92 |
| Changes in Protein during Drying Milk Fish (*Chanos chanos*) at 60°C<br>S. Thippeswamy, K. Ammu & Jose Joseph | 97 |
| Effect of Graded Levels of Dietary Stress Care on Growth, Survival and Body Composition of Common Carp, *Cyprinus carpio*<br>H. Shivananda Murthy & A.T. Ramachandra Naik | 102 |
| Seasonal Variation in Growth and Survival of *Penaeus monodon* Larvae Under Hatchery Conditions<br>J.P. George & Deepa Nair | 106 |
| Growth and Feed Utilization Efficiency of *Osteobrama belangeri* Fed Diets Containing Different Levels of Protein<br>Ch. Basudha & W. Vishwanath | 110 |
| Optimization of Energy to Protein Ratio in Feed for *Labeo rohita* Fingerlings<br>T.A. Sethuramalingam & M.A. Haniffa | 115 |
| Stability in Water and Sinking Rate of Pelleted Feeds Formulated from Locally Available Ingredients<br>A.T. Ramachandra Naik, H. Shivananda Murthy, K.M. Rajesh & Mridula R. Mendon | 121 |
| Training Needs of Shrimp Farmers - An Assessment<br>M. Kumaran & K. Ponnusamy | 125 |
| Marketing Efficiency of Fresh Fish Trade in Cochin and Veraval<br>Nikita Gopal, V. Annamalai, M.P. Remesan & Prem Kumar | 129 |
| Book Review | 133 |
| Author Index | 135 |
| Subject Index | 136 |
| Book Release Announcement | 138 |
| Instructions to Authors | 139 |

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# Cold-anaesthetization and Live Transportation of Penaeid Shrimps

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A review of present practices followed in live transportation of cold-anaesthetised penaeid shrimps is attempted in this paper. Live transportation is used as a means to enhance the unit value of the marketed shrimp. Japanese Kuruma shrimp *Penaeus japonicus* has been found amenable to this practice. Several countries such as Taiwan, Korea, China and recently Australia established a sizeable market for Kuruma shrimp transported alive to Japan, after cold-anaesthetisation. Research on live transportation of other shrimp species such as *Penaeus monodon* has shown encouraging result.

**Key words: Live transportation, cold anaesthetization, shrimp, *Penaeus japonicus***

Live transportation has become one of the most significant practices in the shrimp industry that constantly endeavours to find ways to enhance the final product value. Much research has gone into increasing the marketability of cultured and wild captured shrimp and transporting them live in order to preserve the maximum freshness. This is important, since one of the most favoured destinations of shrimp in the world is Japan where the per capita consumption of fresh seafood is very high. Live shrimp restaurants with ready-to-cook fresh live shrimp are a common sight in Japan. Japanese Kuruma shrimp *Penaeus japonicus* is traditionally transported in live condition.

Raw shrimp has long been appreciated as a delicacy in Japan, the dish being known as *odori ebi* meaning moving shrimp, prepared from fresh live shrimp (Ovenden & Kriz, 1993). Quality of the food prepared from crustaceans is highly dependent on their freshness because of the rapid autolysis that starts immediately after death. The Kuruma shrimp with prime quality has a transparent pale grey coloured body with distinct maroon or brown stripes and a blue tail tinged with yellow. The bands are also very distinctive when cooked, turning from maroon to bright red with fleshy parts turning white. The product should be free from pine smell from the sawdust used for packaging or fishy odour, but should have a mild to sweet flavour (Kriz, 1994).

The present review summarizes the prevailing practices of live transportation as a means for increasing the acceptability of the harvested shrimps. The conditions of live packing for different species and the packing media have also been covered.

## Principles of live transportation

The basic principle behind the technology of live transportation is temperature-induced cold anaesthetization. The water temperature is brought down to a limit at which the metabolic rate of the animal is reduced to a minimum, so that its storage and transport in this condition does not effect any apparent increase in metabolic rate. The movements of the cold-anaesthetised shrimp are minimum, there is no stress caused by vibrations, noise and light; weight loss is usually negligible, and the animals produce no excreta because there is no feed intake and metabolism (Schoemaker, 1991). The shrimps are conditioned for a period of

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time before cold-anaesthetization by starvation, which facilitates effective lowering of metabolic rate at low temperature. Immobilized shrimps are then layered densely using a suitable packing medium such as chilled sawdust. On arrival at the destination, the water temperature is gradually raised to the ambient level, so as to revitalize the shrimp from the anaesthetised state. This ensures maximum freshness of the harvested produce up to the point of final sale.

**Live transportation of Kuruma shrimp**

Live transportation practices have so far been commercially successful only in the case of Kuruma shrimp *P. japonicus*, fetching it very high prices in the Japanese market. Live shipment technology was perfected in Japan way back in the 1960s where wild or cultured Kuruma shrimp, packed in chilled sawdust, were airlifted live to market, in a cold-anaesthetised state (Shigueno, 1992). Earlier reports on live transportation of *P. japonicus* (Noda, 1973; Shigueno, 1975; 1979; Korringa, 1976; Imai, 1977) have provided similar accounts of the various practices in vogue in Japan. Shigueno (1979) reported that *P. japonicus* could tolerate extremely low temperatures and hence low temperature storage and transportation in live condition was convenient.

The cultured shrimps are made to moult at a rapid rate by changing the water quality and diet. Shrimp with hard shells at the inter-moult stage are harvested for packing. Harvesting is usually done using a pound net, pump or electric fishing system, which causes minimum stress during capture. The harvested shrimp are immediately transferred to a net basket or a net tray, which are then placed in aerated cold water tanks with refrigeration coils on the inner wall. The water is then cooled down to a temperature of 12–14°C, over a period of at least 8 h, which makes the shrimp inactive except for movement of their walking legs and pleopods. During mid-summer, the tank water is first cooled down to about 8°C lower than that of the pond water. This is to prevent moulting and to acclimatize the shrimp gradually to the low temperature, which is not necessary in winter. The cold anaesthetized shrimp, which are well tamed and easily handled, are sorted according to size, and weighed in baskets in lots of 2.5–3.0 kg. Packing medium used is sawdust, which is first sun dried and then kept in cold storage at –10°C, in polyethylene or hemp bags. Corrugated hardboard boxes lined with PVC or styrofoam are used for packing. A layer of chilled sawdust is spread on the bottom of the box, followed by a layer of shrimp, which is covered by another layer of sawdust. Three or four alternate layers of shrimp and sawdust are thus placed in the box. The full and tightly packed cartons are then sealed by cellophane tape and stored at 5–10°C in the cold room.

The major countries exporting live *P. japonicus* to Japan are Taiwan, Australia, Korea and China. In 1990, Taiwan monopolized the live shrimp export market to Japan (94%) followed by Korea (4%) and China (2%). However, the outbreak of virus disease in Taiwan and China drastically reduced the production in these countries. During 1990–1993, there was a decline of over 80% in the import of live shrimp from Taiwan. The contributions from other countries also declined in 1993, when Korea exported 1.4%, China 1.15% and Hong Kong 0.2% of the total market size. Recently, Australia succeeded in live shrimp transportation to Japan by exporting sizeable quantities of *P. japonicus* (Anon, 1991; Ovenden, 1993). Japan imported 402 t of live Kuruma shrimp in 1995, Australia being the biggest supplier (Rosenberry, 1996).

Taiwan and Australia employ almost similar technologies for cold-anaesthetisation and live packing of *P. japonicus* as in Japan, except minor variation in the anaesthetizing temperature and the chilling rates. In Taiwan, the temperature of the chilling trough in which the conditioned shrimp in net baskets are kept is lowered by 7-8°C over

a period of 4 h depending on the pond water temperature. During winter, the temperature is lowered from 18°C to 11°C and during other periods, from 25°C to 17°C (Chen, 1990). The packing room temperature is maintained at 10–20°C. One kilogram of shrimp is packed in each box. During summer, a 5 mm thick bag of frozen wet sawdust about the same size of the bottom of the box is placed above the shrimp in each box. The shrimp survive for about 30 h in the insulated boxes.

In Australia, the survival of *P. japonicus* was found to be highest when the shrimps were transported at temperature between 12 and 15°C, but survival improved at 10°C as winter approached (Goodrick *et al.*, 1993). Survival rates in excess of 95% were commercially viable as the product fetched premium prices on arrival at the Japanese markets. In Korea, packing of live *P. japonicus* is done inside a cold room of 10-15°C, and the temperature inside the sawdust box is kept at 15°C (Gil Rho, 1990). Ferdouse (1992) noted that the Kuruma shrimp once destined for Japan alone, was selling at a higher price in local markets of Korea. It was reported that one has to pay a very high price for shrimp in Korea, where the per capita seafood consumption was as high as 47 kg. Similar is the case with Taiwan which exported only 18% of the total harvested *P. japonicus* to Japan, during 1991, and a major share of the rest was sold live in local markets (Chen, 1990). Apart from Japan, Singapore also remained a lucrative market for high value live and fresh shrimp for the neighbouring countries.

**Live transportation of other shrimp species**

The commercial success of live shipment of farmed *P. japonicus* apparently inspired researchers to try these techniques on other species of farmed and wild-caught shrimps. Encouraging results have been obtained in Australia where species such as *P. monodon, P. esculentus, P. semisulcatus* and *P. plebijus* were transported in live condition on trial basis (Goodrick *et al.*, 1995). Farmed *P. monodon*, which were cooled at a rate of 3°C per hour to 12°C and packed in chilled sawdust survived for about 24 h. However, the survival of farmed *P. monodon* was slightly better at 16°C than at 12°C. In Australia, *P. monodon* farms form the mainstay of the shrimp culture industry. However, with the insatiable demand in Japan for live *P. japonicus*, intensive *P. japonicus* farms are also seen to flourish. Research in Australia on live transportation is mainly aimed at catering to the Japanese markets. The wild brown tiger shrimp, *P. esculentus*, abundantly obtained from trawl catches, have maroon or brown stripes like Kuruma shrimp and were favoured for their attractive appearance. However, they are not normally cultured in Australia, unlike the Kuruma shrimp, which though uncommon in Australian waters, are grown in ponds and exported live to Japan.

Goodrick *et al.* (1995) suggested that taking advantage of the similarity of the brown tiger shrimp with the Kuruma shrimp, a live market for the former could be developed using shrimp from the capture fishery. When wild *P. esculentus* that had apparently recovered from the stress due to capture were tested, they survived for 12-18 h, after being cooled at the rate of 3°C per hour, and packed in chilled sawdust at 12°C. Wild caught *P. semisulcatus* also showed a similar response. These results did not favour commercial trials, since survival for at least 24 h is required for overseas marketing from Australia. Further, farmed *P. esculentus* did not survive in sawdust as long as *P. monodon* caught at the same farm, though the result was confounded by evidence that the brown tiger shrimp at the farm were in poor condition. Goodrick *et al.* (1995) also reported that the observation while handling *P. esculentus* at 12°C indicated that this temperature might be too cold. Therefore, they suggested that the survival of *P. esculentus* might be slightly extended by maintaining higher temperatures (about 15°C) rather than the 12°C

routinely used for shipping Kuruma shrimp, though there are doubts that this temperature would immobilize the brown tiger shrimp. It may be noted that as reported by Paterson (1993), the Kuruma shrimp experience no metabolic stress when held in sawdust at 12°C.

Experiments conducted at the Fisheries College, Cochin revealed that 14±1°C is the optimum temperature at which farmed *P. monodon* could be cold-anaesthetized for live storage in chilled sawdust (Salin, 1997). Of the three chilling rates tested, the moderate chilling rate (2.76±0.32°C), which took 4 h to effect cold-anaesthetization, was found to be the optimum, though the choice of different chilling rates depended on the duration of live storage desired. A statistically valid safe duration (for obtaining 100% survival) of 22.9±1.09 h was obtained by employing a chilling rate of 1.38±0.16°C which took 8 h for cold-anaesthetization. This clearly shows that *P. monodon* could be safely kept live under cold storage in chilled sawdust for up to 24 h, signifying its potential for live transportation.

Huq *et al.* (1991) suggested that simulated hibernation of *P. monodon* of marketable size could be done at about 8°C, both in summer and winter. Huq *et al.* (1994) conducted simulated hibernation experiments using 5 month old *P. mondon* and found that dormant shrimp kept in chilled sawdust with 5% moisture and guarded by 2 outer layers of relatively colder, frozen sawdust with 10% and 15% moisture in an insulated box could be kept under hibernation with survival rates of 100, 86, 70 and 60.5% after 12, 18, 24 and 27 h, respectively.

In Taiwan, the red tail shrimp *P. penicillatus* was subjected to cold-anaesthetization studies. However, it did not survive out of water and was not found suitable for live transport (Liao & Chien, 1990).

The white-legged shrimp *P. vannamei*, one of the major species of cultured shrimps in Central and South America, has been tested for live transportation in South Carolina, USA (Jiang *et al.*, 1995). After acclimatisation from 27°C, the shrimps were packed in boxes with absorbent paper as the medium, and kept in a refrigerated chamber at 14°C. The mean survival after shipment/storage was found to be inversely related to the rate of chilling: i.e., chilling rates of 1-2°C, 3-4°C and 5-6°C per hour resulted in average survival rates of 86.4, 77.6 and 56% respectively. The shrimp revived almost completely when reacclimatized from 14°C to 27°C at the rate of 3-4°C per hour. It was also found that an initial increase or decrease in temperature of up to 7°C for acclimatisation had no adverse effect on survival.

Although several species of shrimps have been tried and found successful for live transportation, there has not yet been a ready market available for any of these species, unlike that for *P. japonicus*. The consumer preference is unique for *P. japonicus* in Japan and shrimps having similar appearance such as *P. esculentus*, need to be further tried to substitute *P. japonicus* in the live shrimp market.

**Packing media**

Sawdust seems to be the most common material used as packing medium in commercial live transport of shrimps. In Japan, coarse sawdust of Cedar tree *Cryptomeria japonica* locally called *Sugi* is usually used (Korringa, 1976). The sawdust used should be low in resin, untreated and pesticide-free. One of the characteristic features of sawdust is that it is a poor conductor of heat, light in weight and since it contains minute air spaces, respiration of the shrimp, though minimum, is unaffected (Imai, 1977). However, the sawdust sometimes removes the water remaining in the gills or on the body of the shrimp during transit and leads to dehydration of the packed animals. Therefore, other packing materials have also been investigated.

Imai (1977) described a commercial product called *parite* which when moistened

remained cold for a longer time and was about 30% lighter than sawdust, giving better survival rates of packed animals than sawdust, but more expensive. Schoemaker (1991) suggested the substitution of sawdust with algae or seaweeds with the added advantage that algae also humidified the packed shrimps. Huq *et al.* (1994) found sawdust to be the best packing medium when compared to rice husk and wheat bran. Jiang *et al.* (1995) used absorbent paper as the medium for packing cold-anaesthetized *P. vannamei*. Packing the cold anaesthetized shrimps in an ambience of oxygen was also investigated. Imai (1977) reported that the sawdust packs without oxygen were more economical in terms of the better survival rates obtained, than when the sawdust packs were kept airtight in boxes filled with oxygen. Jiang *et al.* (1995) however, reported that packing of *P. vannamei* after cold-treatment in pure oxygen markedly improved survival when compared to that in air. Oxygen also appeared to increase resistance of the shrimps to lower temperature.

Critical biological criteria have to be fulfilled while shipping cold-anaesthetized live crustaceans (Richards-Rajadurai, 1989). The condition of the animal before shipping, maintenance of low storage temperature, maintenance of appropriate humidity and prevention of stress and drying are very important.

## Cultured shrimp and live transportation

Aquaculture products enjoy distinct advantages over capture fisheries as far as live marketing is concerned (Subasinghe, 1996). Harvesting could be suitably timed for maximum benefit. The quality and uniformity of the product would improve the marketability compared to capture fisheries. The farmers could also adopt stock manipulation to suit specific customer preferences. Live export of penaeid shrimps thus offers a challenging opportunity for aquaculturists. The expanding demand for live shrimps all over the world, and the competitive advantage of aquaculture over capture fisheries suggest that the outlook for live shrimp market is extremely positive.

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*Fishery Technology*
2001, Vol. 38(2) pp : 77 - 80

# Comparative Fishing Efficiency of Lobster Traps

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Fishing efficiency of lobster traps relies on various factors like design, shape and material of the trap and bait used. Investigations on suitable design for lobster trap was attempted using six different designs such as rectangular with synthetic webbing, rectangular with steel wire, hemispherical, circular, semi-cylindrical and trapezoidal. The fishing efficiency of the traps differed significantly ($p<0.01$). Semi-cylindrical trap performed well by trapping 53 numbers of lobsters in 30 fishing operations.

**Key words: Lobster trap, trap design, bait, comparative efficiency**

Trap is a selective fishing gear suitable for capturing the ideal size groups of target species. It is a conventional and versatile gear and is a suitable device to fish even in rough fishing ground with rocks and corals (Rajan & Meenakumari, 1982). It is generally used in small-scale fishery. (Buesa, 1965; George, 1973). Colachal trap made of palmyra leaf-stalk is used as traditional gear in south-west coast of India (Miyamota & Shariff, 1961). Bio-degradable nature of this trap leads to quick damage and short life. Catching ability of the traps mainly depends on the shape of the trap, though various other factors also influence it (Munro, 1974; Recksiek *et al.*, 1991). Among different designs of lobster traps, Canadian parlor cum bedroom trap has been found to perform better over the Scottish creels and Cornish ink-well traps (Bruin, 1980). Australian pots and rectangular pots were reported to be more efficient than ink-well pots to catch lobsters (Rajan & Meenakumari, 1982). Rajan *et al.* (1988) reported that trap of semi-cylindrical shape performed better than traditional traps used by fishermen of south-west coast of India. The present study deals with the comparative fishing efficiency of six different designs of traps having equal volume.

## Materials and Methods

Six different designs of traps with a volume of 0.225 $m^3$ each were fabricated in triplicates. The traps varied from one another in shape. They were rectangular box with synthetic webbing as covering material (A), rectangular box (B), hemispherical trap (C), circular trap (D), semi-cylindrical trap (E) and trapezoidal trap (F). All the traps had iron framework made up of 10 mm mild steel (MS) rods. In design A, polyethylene (PE) webbing having 60 mm mesh size and 1 mm twine size was used as external covering material over the iron framework and nylon webbing of 11 mm mesh size was used around the funnel. In other traps, MS wire mesh with rectangular mesh of size 50x25 mm (wire dia, 1 mm) was used as covering material. Wire mesh was suitably cut according to the design of the trap and welded to the iron framework. All the traps were provided with a truncated funnel, having slight downward curvature at the rear end in order to prevent the escapement of the trapped lobsters. The diameter of outer and inner rings of the funnel were 300 mm and 120 mm, respectively and the rings were interconnected with 24 numbers of MS rods bent in suitable shape. All the traps had the mouth at the side except trap C where mouth was at the top. To facilitate placing

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of bait and removal of entrapped lobsters, a vent was provided at the rear end in all the traps. The traps thus made were coated with epoxy resin to avoid corrosion.

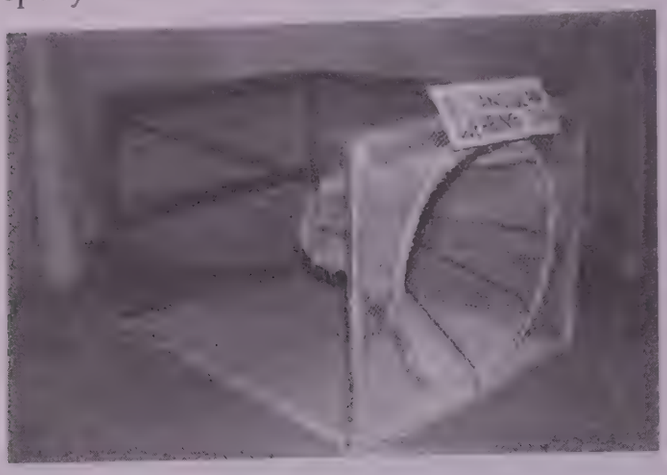

Fig. 1. Rectangular Box trap with synthetic webbing (A)

The framework of trap A was rectangular with the dimensions of 750x600x500 mm and the base area of 0.45 $m^2$ (Fig. 1). Trap B was identical to trap A in all respects and differed only in covering material used (Fig. 2).

Fig. 2. Rectangular Box trap (B)

Trap C has a round bottom with base area and diameter of 0.71 $m^2$ and 950 mm, respectively. Additional MS rods were attached to the base to increase strength at the bottom. In this trap, mouth was provided by bending six wands at the top. The depth of the trap was 476 mm (Fig. 3). Trap D had upper and bottom rings of identical diameter (950 mm). Base area and the height of the trap were 0.71 $m^2$ and 317 mm, respectively. The upper and bottom rings of this trap were interconnected with 4 MS rods and reinforced with two rods across (Fig. 4).

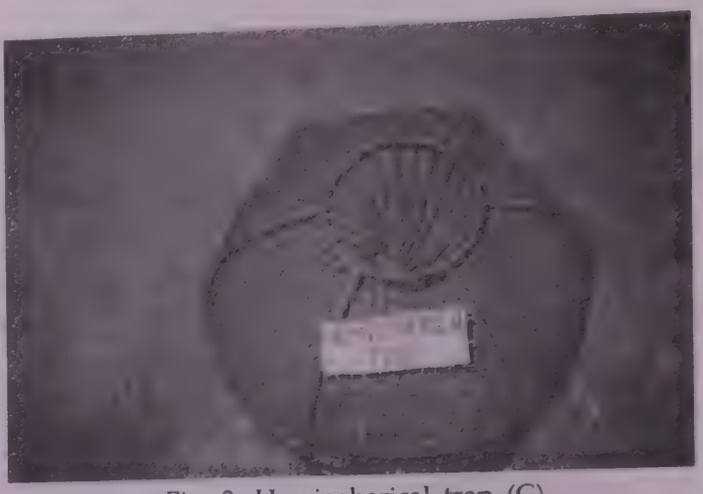

Fig. 3. Hemispherical trap (C)

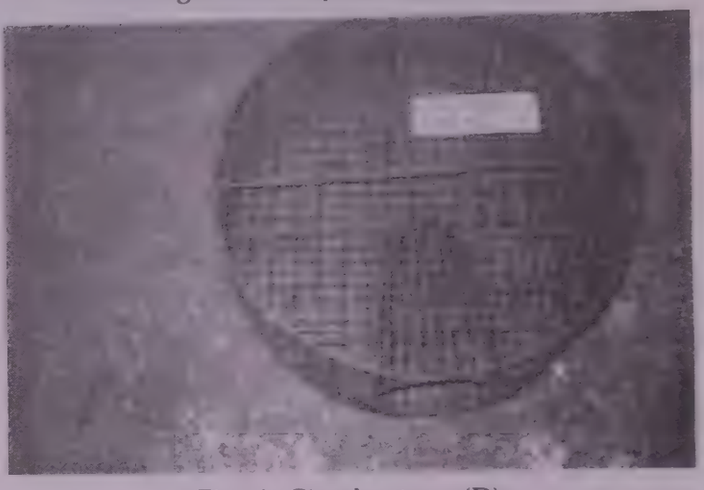

Fig. 4. Circular trap (D)

Trap E had a semi-cylindrical shape with length of 945 mm, breadth of 750 mm and height of 404 mm and base area of 0.71 $m^2$. This trap was made by bending two MS rods in semicircular manner and connecting them at fore and rear end of the rectangular base. These two rings were interconnected by welding a longitudinal rod at the top. Additional rods were welded across the base of the trap as reinforcement (Fig. 5). Trap F was made by connecting two rectangular frames, one at the top and another at the

Fig. 5. Semi-cylindrical trap (E)

bottom with four vertical MS rods. The top frame had a dimension of 750x300 mm and the bottom frame 750x600 mm (Fig. 6).

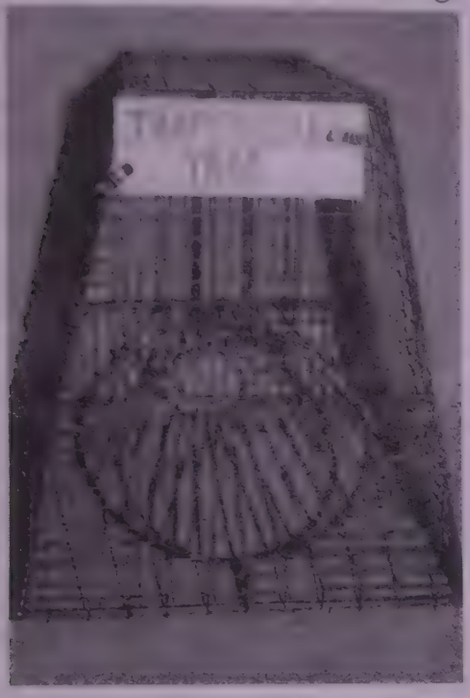

Fig. 6. Trapezoidal trap (F)

All the experimental traps were tested at *Enayam* (8° 13′ N; 77° 11′E) situated along the south-west coast of India, a well known fishing ground for spiny lobster fishery (Rajan *et al.*, 1985). Three traditional traps (T) popularly called as *Colachal* trap (Fig. 7), were used as control during comparative fishing experiments. Thirty fishing operations were carried out from January to April 1994.

All the traps were baited with 80-100 numbers of live brown mussel (*Perna indica*) prior to transportation to the fishing ground. Three batches of traps were deployed at the

Fig. 7. Traditional trap (T)

bottom at a depth of 3-8 m by skin diving in the sequence of A-C-D-B-E-F-T, at an interval of 4-6 m from each other. The position of trap in each batch was changed on rotational basis after every operation to minimize the sampling error. Traps were kept immersed for 24 h for every operation. At the end of each operation, data on number of lobsters caught and total length and weight of individual lobsters were recorded. The catch data were analyzed by ANOVA technique to find out the influence of design over the efficiency of the trap.

## Results and Discussion

In general, catching efficiency of a lobster trap depends on its design (Munro, 1974; Recksiek *et al.* 1991). Trap design should suit local conditions such as nature of the ground, depth of the water and strength of tide, for successful operations. In addition to catching efficiency, features such as stability, durability, robustness and ease of handling are important in trap design.

Table 1. *Panulirus homarus* caught in various designs of traps

| Trap design | No. of traps set | Total fishing operations | Lobsters caught | | Mean carapace length (mm) | Mean total length (mm) | Mean weight (g) |
|---|---|---|---|---|---|---|---|
| | | | No. | Weight (kg) | | | |
| A | 3 | 30 | 6 | 3.79 | 123.50±35.70 | 271.82±35.71 | 631.67±148.42 |
| B | 3 | 30 | 1 | 0.24 | 93.42 | 210.05 | 240.00 |
| C | 3 | 30 | 6 | 2.3 | 112.81±11.24 | 244.81±15.21 | 383.33±81.71 |
| D | 3 | 30 | 2 | 1.05 | 107.24±2.95 | 243.44±10.60 | 525.00±25.00 |
| E | 3 | 30 | 53 | 16.77 | 90.86±23.14 | 197.91±49.85 | 316.42±191.92 |
| F | 3 | 30 | 6 | 3.18 | 109.27±28.76 | 248.13±62.56 | 530.00±294.13 |
| T | 3 | 30 | 6 | 2.0 | 89.51±23.61 | 193.62±51.41 | 333.30±206.51 |
| Overall | 21 | 210 | 80 | 29.33 | 102.64±19.37 | 228.15±31.91 | 421.72±156.64 |

In the present study, during normal weather conditions all the traps, irrespective of the design, were equally stable on the sea bottom. However, during rough weather conditions, the traps A, B and F were found to be dislocated. This might be attributed to the smaller base area of these traps. Further, the poor stability of trap A was due to inadequate ballasting. Prudden (1951) has reported that trap designs less than 46 cm in height would reduce the tendency of the trap to overturn during operation. Therefore, relatively greater height and tapered upper edge might be the reason for the poor stability of trap F. Among the traps tested, trap E was identified as the best trap in view of easy handling and placement in the crevices. The advantages of trap E were its appropriate shape without projections and good stability. Though the traps D and B offered good stability over even bottom, the shape of these traps prevented their placement in crevices between the rocks. Disadvantages noted with respect to trap C, were (i) wastage of wire mesh during fabrication, (ii) requirement of comparatively more deck space to carry them to fishing ground and (iii) poor stability on uneven bottom.

The catch data revealed that the performance of the trap E was better than other traps as it could catch lobsters about 9 times more than traps A,C,F and T (Table 1). The catch from trap E was significantly high ($p<0.01$) compared to other traps (Table 2). The difference in catching efficiency may be attributed to the variation in shape and stability of the traps (Rajan & Meenakumari, 1982). The catching ability of the traps A, C and F did not differ significantly from traditional trap (T). However, the total weight of lobsters caught in these traps was a little more than that in the traditional trap. Meenakumari & Rajan (1985) reported that the entangling of legs of lobsters with the PE webbing of funnel would ultimately reduce the efficiency of the trap. However, this was prevented in the present study by providing an additional layer of nylon webbing with small meshes (11 mm) inside PE webbing having bigger meshes (60 mm). Poor catch obtained from trap B could be due to unfavorable orientation of traps to the burrows and poor stability and not due to entanglement of lobsters with webbing. Trap C with the top entrance showed poor performance (Temple, 1964; Rajan & Meenakumari, 1982). Among the traps tested, trap E with semi-cylindrical shape performed better in all respects. Hence, this trap can be recommended for commercial operation after suitably reducing its size.

Table 2. Results of statistical analysis (ANOVA)

| Source of variation | df | SS | MSS | F-ratio |
|---|---|---|---|---|
| Between replicates | 2 | 32.09 | 16.045 | |
| Between designs | 6 | 681.238 | 113.539 | 2.137 NS |
| Error | 12 | 123.90 | 10.325 | 10.996** |

** Significant ($p<0.01$) at % level; NS = Not significant

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*Fishery Technology*
2001, Vol. 38(2) pp : 81 - 83

# Relative Fuel Consumption and Effective Fishing Time of Small-scale Mechanised Gillnetters, off Cochin

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The drift gillnet operation is one of the important low energy fishing methods in small scale fishing sector along the Indian coast. The gillnet operations have undergone considerable change in the form of increased length class and horse power of fishing crafts employed, which enable the vessels to operate at distant fishing grounds and with enhanced operational efficiency. An understanding of effective fishing time and fuel efficiency will lead to considerable improvement in operational efficiency of gillnetters. The analysis of the effective fishing time and relative fuel consumption among the selected length classes of gillnetters operating from Cochin Fisheries Harbour showed that effective fishing time increased with increase in length overall and the relative fuel savings was higher in length 31-35′ class vessels.

**Key words: Fishing time, fuel consumption, gillnetter**

The mechanization of gillnetters along the inshore waters off Cochin started in 1969 with the introduction of about 90 gillnetters. With the commissioning of Cochin Fisheries Harbour in 1977, the number of vessels increased to 130 (Silas *et al.*, 1984). Since then, the number has increased considerably. Their size varies from 26 to 40′ length overall and installed engine power varies from 60 to 90 hp. The vessels are capable of extending their fishing operations up to 6 days and have a crew complement of 4 to 6. Among these the smaller vessels are exclusively operating for drift gill netting. When the drift net operation is not much profitable from October to March, vessels above 35′ $L_{OA}$ shift to line fishing for reef-cod, snapper and sharks.

Being one of the low energy fishing techniques, gillnetting occupies a unique position from the energy conservation point of view. The drift gillnet fishery has not undergone much advancement from its initial state. Even though the process of mechanization primarily started with gill-netters, mechanization in gillnetting is still used only for propulsion to and from the fishing ground. The handling of the gear and catch has not undergone any change from the initial practice of manual operation of the gear. Fuel cost forms a major component of the operational expenditure and it has increased continuously over the years (Panikkar *et al.*, 1990; Shibu, 2000). So far, no attempt has been made to study the relative fuel consumption and effective fishing time patterns of the mechanized gillnet operations, off Cochin. An under-standing of the above factors will help to improve the efficiency of fishing operations and hence the present study was undertaken to find out the vessel classes having optimum fuel use and better effective fishing time.

## Materials and Methods

The sample units for data collection were selected from the existing length classes of vessels and for making the comparison more effective, they were classified into length groups. Representative samples were drawn from each length class by simple random method and the sampling fractions were 2.1, 2.4 and 2.1 respectively of 26-30′, 31-35′ and 36-40′ length class gillnetters. A

structured questionnaire was used to collect data regarding general details of fishing craft like length overall, horse power of engine, type of gear used, investment patterns of craft and gear etc. Data on operational details like duration of voyage, depth of operation, fuel consumption, total running time of engine and effective fishing time were collected at 10 days interval for one year from January 1997 to December, 1997. The effective fishing time or actual fishing time is taken as a sum of soaking time and hauling time. As the size of the gear used was same, the shooting time of the gear was more or less constant and was not considered in calculations of effective fishing time.

**Results and Discussion**

Operational details of mechanized gillnetters, operating from Cochin Fisheries Harbour, during the period of study, are given in Table 1. Mean installed engine horse power of the three length classes of gillnetters viz., 26-30′, 31-35′ and 35-40′ $L_{OA}$, were 60, 65 and 70, respectively. Total number of fishing trips undertaken by the three length classes were respectively, 130, 98, 99. The duration of fishing trips varied with the seaworthiness of the vessel, fish hold capacity, climatic factors and availability of resources. The mean duration of fishing trips for 26-30′ $L_{OA}$ gillnetters was 2.3 days. It increased to 2.7 days in 31-35′ $L_{OA}$ gillnetters and 3.2 days in 36-40′ $L_{OA}$ gillnetters. Thus, higher length class gillnetters had potential for increasing effective fishing time per trip, compared to smaller vessels. Mean effective fishing time varied from 177 h in small to 1879 h in medium and 2527 h in large length class gillnetters. Percentage of running time of engine to effective fishing time was highest in small length class gillnetters (97.47%), followed by medium (75.24%) and lowest in large length class gillnetters (69.88%) (Table 1.).

Small mechanized gillnetters operating from Cochin utilize engine power only for propulsion. Hauling of the gear is done manually. There is scope for introduction of mechanized system for gillnet hauling, using power take-off from main engine or by using hydraulics. This would permit longer duration of soaking and/or operation of longer fleet of nets. Considerable savings in manpower requirement in the gillnetting operation is also possible by introduction of mechanized hauling system.

Table 1. Operational details of mechanized gillnetters operated from Cochin

| | $L_{OA}$ | | |
|---|---|---|---|
| | 26-30′ | 31-35′ | 36-40′ |
| 1. Mean horse power | 60 | 65 | 70 |
| 2. Total number of trips | 130 | 98 | 99 |
| 3. Mean trip duration (days) | 2.3 | 2.72 | 3.20 |
| 4. Total number of fishing days per year | 304 | 267 | 317 |
| 5. Mean catch landed per trip (kg) | 204.6 | 261.5 | 316.1 |
| 6. Mean effective fishing time (h) | 1777 | 1879 | 2527 |
| 7. Percentage of engine running time to mean effective fishing time | 97.37 | 75.24 | 69.88 |
| 8. Mean fuel consumption per trip (l) | 112.68 | 141.68 | 199.49 |
| 9. Mean fuel consumption ($l.h^{-1}$) | 8.47 | 9.82 | 11.19 |
| 10. Mean fuel consumption per kg of fish (l) | 0.55 | 0.54 | 0.63 |

Average fuel consumption per trip was 112.68 l in 26-30′ length class, 141.68 l in 31-35′ length class and 199.49 l in 36-40′ length class gillnetters. Mean fuel consumption per hour showed a similar trend and increased from 8.47 $l.h^{-1}$ in small to 9.82 $l.h^{-1}$ in medium and 11.10 $l.h^{-1}$ in large length class gillnetters.

Mean catch landed per trip was 204.6 kg in small, 261.5 kg in medium and 316.1 kg in large length class gillnetters. Fuel consumption per kg of fish landed by different length classes of gillnetters increased from about 0.5 $l.kg^{-1}$ for small and medium length class to 0.6 $l.kg^{-1}$ in large gillnetters (Table 1).

Fuel consumed per day per trip for single or multi-day operation undertaken by

Table 2. Fuel consumption per day per trip of different length class of gillnetters during single and multi-day fishing operations

| Vessel class | Fuel consumption ($l.day^{-1}.trip^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | 1-day trip | 2-day trip | 3-day trip | 4-day trip | 5-day trip | 6-day trip |
| 26-30′ | 100 | 70 | 52 | 60 | 72 | – |
| 31-35′ | 125 | 77 | 62 | 72 | 73 | – |
| 36-40′ | 134 | 88 | 77 | 86 | 89 | 92 |

the vessels of three different length class is given in Table 2. For single day trips, fuel consumption ranged from 110 l for small, 125 l for medium and 134 l for large gillnetters. In small gillnetters, 36.4% fuel could be saved when undertaking 2-day trips and 53.7% saving is possible when the vessel is undertaking 3-day trips. However, percentage savings in fuel reduced afterwards, being only 45.5% for 4-day trips and 34.6% for 5 day trips (Fig.1).

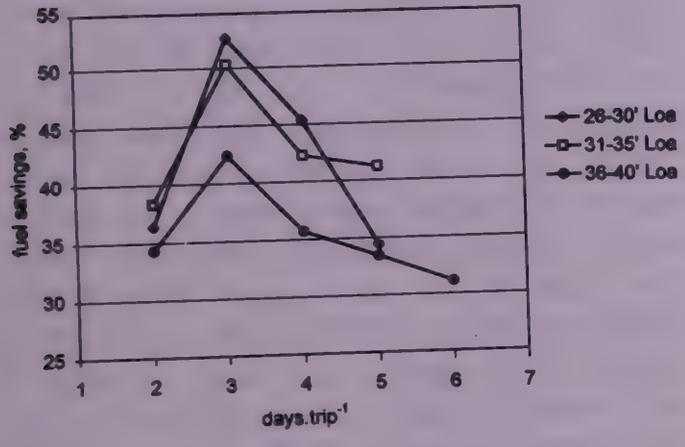


Fig. 1. Fuel savings in multi-day fishing trips compared to single-day operations in different length classes of gillnetters.

Similar trend in fuel savings was observed in the other two length classes of gillnetters (Fig.1). Fuel savings showed an increasing trend up to 3 day voyages in all length classes. As the number of days of fishing trip increased further, there was a decline in the percentage fuel savings. However, overall benefits of fuel saving in multi-day operations were maintained.

The study has revealed the importance of multi-day operation as an important fuel saving measure in gillnetting operations, which is effective irrespective of length classes. In addition, multi-day operations also provide benefits in terms of increased effective fishing time.

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*Fishery Technology*
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# Optimization of Mesh Size of Gill Nets for *Sardinella gibbosa* (Bleeker)

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Fishing conducted in inshore waters off Thoothukkudi (Tamil Nadu) during 1997-98 using 16 units of nylon gill nets with 26, 28, 30 and 32 mm mesh size made up of 210D/1/2 twine revealed that the proportionality co-efficient (k) of the gill net selectivity equation for *Sardinella gibbosa* was 0.104. Gill net with mesh size 29.6 mm was found to be ideal for the commercial exploitation of *S. gibbosa* which contributes considerably to the lesser sardine fishery of Thoothukkudi coast. The details of enmeshing pattern of different length groups of *S. gibbosa* in gill nets of different mesh sizes are presented.

**Key words: Mesh size, gill nets, *Sardinella gibbosa*, selectivity**

Attempts have been made in India to optimize the mesh sizes for commercial exploitation of different inland and marine fishes (Joseph & Sebastian, 1964; Sulochanan *et al.*, 1968; Sreekrishna *et al.*,1972; Sulochanan *et al.*, 1975; Khan *et al.*, 1989; Kartha & Rao, 1991; Neethiselvan *et al.*, 2000). Luther *et al.*, (1994) studied the role of gill nets in the exploitation of lesser sardines at Visakhapatnam inshore area and concluded that the operation of gear having mesh size less than 28 mm must be discouraged for ensuring sustained lesser sardine fishery in the region.

In Thoothukkudi inshore waters, *Sardinella gibbosa* is captured using both shore seines and gill nets. However, gill nets are largely employed for capturing this species. Fishermen of this coast use gill nets of various mesh sizes ranging from 25 to 36 mm, leading to indiscriminate capture of this species. In this study, an attempt was made to determine the optimum mesh size for the commercial exploitation of *S. gibbosa*, which forms a notable fishery from June to August along this coast.

## Materials and Methods

Gill nets of mesh size 26, 28, 30 and 32 mm each, in quadruplicate, were made from machine-made nylon webbing, fabricated using 210D/1/2 twine. The nets with mesh size 26, 28, 30 and 32 mm used in this study were designated as A, B, C and D, respectively. During the operation, all the sixteen nets were connected serially and a total of 50 fishing operations were carried out, off the ship anchorage of Thoothukkudi Port from 4 am to 7 am. The fishing operations were carried out from January to August 1997 using a 20 footer plank-built boat powered with a 10 hp inboard engine. After every operation, the fish caught in each net were segregated and morphometric measurements such as total length, gilled girth and maximum girth were recorded. According to Baranov (1948), mesh size of gill nets is proportional to modal length of fish caught by it. Proportionality coefficient, k, was determined as per the method described by Baranov (1948).

## Results and Discussion

The details of average fish catch per operation of the nets A, B, C and D are given in Table 1. Details such as number of fishes examined, length range, and mean length of *S. gibbosa* captured in different nets are given in Table 2. The length frequency distribution expressed as percentage of the fish caught in

Table 1. Average fish catch per operation of experimental gill nets

| Gear | Catch per unit (nos.) | Total catch (nos.) |
|---|---|---|
| A | 378 | 1512 |
| B | 406 | 1624 |
| C | 224 | 986 |
| D | 84 | 336 |

Table 2. Details of fish caught in experimental gear

| | Nets | | | |
|---|---|---|---|---|
| | A | B | C | D |
| No. of fish examined | 235 | 250 | 180 | 175 |
| Length range (mm) | 10.50-14.20 | 12.00-14.50 | 14.10-15.70 | 14.40-17.00 |
| Mean length (mm) | 12.26±2.03 | 13.43±1.11 | 14.81±1.80 | 15.52±1.50 |

Table 3. Length frequency distribution as percentage of *Sardinella gibbosa* caught in nets A, B, C & D

| | Nets | | | |
|---|---|---|---|---|
| | A | B | C | D |
| 111-115 | 10.1 | 0 | 0 | 0 |
| 116-120 | 15.1 | 8.7 | 0 | 0 |
| 121-125 | 27.6 | 13.0 | 0 | 0 |
| 126-130 | 24.5 | 16.3 | 12.5 | 0 |
| 131-135 | 13.0 | 22.4 | 12.7 | 0 |
| 136-140 | 6.0 | 29.0 | 18.5 | 0 |
| 141-145 | 3.7 | 10.6 | 31.3 | 32.3 |
| 146-150 | 0 | 0 | 14.5 | 43.3 |
| 151-155 | 0 | 0 | 10.5 | 18.7 |
| 156-160 | 0 | 0 | 0 | 5.7 |

different nets is given in Table 3. Enmeshing pattern of *S. gibbosa* in different experimental nets is given in Tables 4, 5, 6 and 7.

On analyzing the growth stages of the fish caught in the nets A, B, C and D, it was evident that most of the fish caught in the net A were either juvenile or maturing animals. The catch from the nets B, C and D were mostly constituted by mature and spent fishes. Since the net D could capture only a few fishes, the fishes caught from this net were excluded for the estimation of 'k'. The estimated k value based on the $l_o$ (130 mm) derived from the length frequency data of the nets A and B was 0.1037 and the value

Table 4. Enmeshing pattern of various size groups of *Sardinella gibbosa* in gill net 'A'

| Size range in cm | Percentage of enmeshing | | |
|---|---|---|---|
| | Before opercular margin | At opercular margin | Between opercular margin and maximum girth |
| 111-115 | – | 65 | 35 |
| 116-120 | – | 68 | 32 |
| 121-125 | – | 70 | 30 |
| 126-130 | – | 86 | 14 |
| 131-135 | 2 | 98 | – |
| 136-140 | 8 | 92 | – |
| 141-145 | 14 | 86 | – |
| 146-150 | 8 | 82 | – |
| 151-155 | 25 | 75 | – |
| 156-160 | 30 | 70 | – |

Table 5. Enmeshing pattern of various size groups of *Sardinella gibbosa* in gill net 'B'

| Size range in cm | Percentage of enmeshing | | |
|---|---|---|---|
| | Before opercular margin | At opercular margin | Between opercular margin and maximum girth |
| 111-115 | – | – | – |
| 116-120 | – | 82 | 18 |
| 121-125 | – | 94 | 6 |
| 126-130 | – | 100 | – |
| 131-135 | – | 100 | – |
| 136-140 | – | 100 | – |
| 141-145 | 7 | 93 | – |
| 146-150 | – | – | – |
| 151-155 | – | – | – |
| 156-160 | – | – | – |

of $l_o$ and k derived from the length frequency data of the nets B and C were 139 mm and 0.1042, respectively. The average value of k was worked out to be 0.104. Taking this value of k, the mesh size required for the exploitation of commercially significant size group (141–145 mm) was 29.6 mm (i.e., 142.5 x 0.104 = 14.8 mm; 2 x 14.8 = 29.6 mm).

The length group 141-145 mm formed 17% of the commercial landings (Table 8) and this length group comprised of mainly spawning and spent animals. The commercially important size group of 141-156 mm

Table 6. Enmeshing pattern of various size groups of *Sardinella gibbosa* in gill net 'C'

| Size range in cm | Percentage of enmeshing | | |
|---|---|---|---|
| | Before opercular margin | At opercular margin | Between opercular margin and maximum girth |
| 111-115 | – | – | – |
| 116-120 | – | – | – |
| 121-125 | – | – | – |
| 126-130 | – | – | – |
| 131-135 | – | – | – |
| 136-140 | – | 92 | 8 |
| 141-145 | 15 | 79 | 6 |
| 146-150 | 24 | 72 | 4 |
| 151-155 | 30 | 70 | – |
| 156-160 | 32 | 68 | – |

Table 7. Enmeshing pattern of various size groups of *Sardinella gibbosa* in gill net 'D'

| Size range in cm | Percentage of enmeshing | | |
|---|---|---|---|
| | Before opercular margin | At opercular margin | Between opercular margin and maximum girth |
| 111-115 | – | – | – |
| 116-120 | – | – | – |
| 121-125 | – | – | – |
| 126-130 | – | – | – |
| 131-135 | – | – | – |
| 136-140 | – | – | – |
| 141-145 | – | – | – |
| 146-150 | – | 92 | 8 |
| 151-155 | – | 95 | 5 |
| 156-160 | – | 98 | 2 |

was properly enmeshed at opercular margin in the nets B and C to the extent of 93% and 79%, respectively (Tables 5 & 6) and the proposed mesh size of 29.6 mm falls between the mesh size of the nets B and C. Further, it is suggested that the use of nets with mesh size 26 mm and less should be discouraged so as to avoid capturing juveniles in order to prevent 'growth over-fishing' of *S. gibbosa* off Thoothukkudi coast.

Table 8. Composition of landings of *Sardinella gibbosa*

| Length range (mm) | Percentage composition |
|---|---|
| 111-115 | 2.0 |
| 116-120 | 5.0 |
| 121-125 | 10.0 |
| 126-130 | 15.0 |
| 131-135 | 15.0 |
| 136-140 | 16.0 |
| 141-145 | 17.0 |
| 146-150 | 12.0 |
| 151-155 | 5.0 |
| 156-160 | 2.0 |

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*Fishery Technology*
2001, Vol. 38(2) pp : 87 - 91

# Changes During Frying of Mackerel at Different Temperatures

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Rate of heat penetration to the centre of fish piece (mackerel) during frying was studied at two selected temperatures of 120°C and 160°C by inserting needle type thermocouple. Heat penetration rate to the centre of fish piece was slower at 120°C than at 160°C. At 120°C, centre temperature did not reach 100°C even after prolonged frying; whereas at 160°C, it crossed 100°C after 16 min of frying. Effect of variation in frying temperature and time on frying loss, moisture content and moisture loss of fried fish were studied in detail. Biochemical changes in fish during frying and the oil consumption rate were estimated at four treatments viz., 120°C for 18 min, 140°C for 10 min, 160°C for 5 min and 180°C for 5 min. Parameters like moisture, crude protein, crude fat, total ash, salt, TVB-N, TMA-N, PV, FFA and caloric values were analysed. There was a sharp increase in TVB-N, TMA-N, PV and FFA content in fish during frying.

**Key words: Heat penetration, deep frying, biochemical characteristics, mackerel**

Frying fish in oil is an age-old culinary practice in all parts of our country and one of the best methods for preparing the fish for direct consumption (Chand & Maragal, 1990). In India, where taste, food habit, culture and preference of people are so diverse, the development of various products from fried fish is likely to increase the consumer appeal. Frying is also adopted as a method of pre-cooking in fish canning and it is being practised in several countries. According to Cheftel (1965), frying is the traditional way of preparing sardine for canning.

Since fish is subjected to severe heat treatment during frying, it has several effects on the physical and biochemical characteristics of the fish. Temperature and time are the two critical factors that should be carefully controlled during frying. In this experiment, attempt was made to study the heat penetration rate and changes in biochemical characteristics during deep-fat frying of mackerel.

## Materials and Methods

Fresh mackerels (*Rastrelliger kanagurta*) were dressed by removing fins, head and viscera. The dressed fish were cut into 5 cm pieces and washed properly. Pieces were brined for 1 min in saturated solution. After a quick wash, the pieces were deep fried in groundnut oil at four time-temperature treatments, viz., 120°C for 18 min, 140°C for 10 min, 160°C for 5 min and 180°C for 5 min. Temperature during frying was maintained by adjusting the flame of the gas stove. During frying, constant temperature was maintained for most of the time, except a maximum temperature variation of 5°C during the initial part of frying in each batch. Up to 500 g of fish were fried in each batch and care was taken to fry both body pieces and tail pieces almost in equal proportion in each batch.

The rate of heat penetration to the centre of fish pieces during frying was

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studied at 120°C and 160°C by inserting the needle type thermocouple into the centre of the fish pieces. The thermocouples were provided with suitable lead wires of sufficient length which could be connected to the temperature reading instrument directly through a connection box to an automatic self compensated digital thermometer with a reading accuracy of ±0.1°C and measuring range of –60°C to 199.0°C (Ellab Instruments, Copenhagen, Denmark).

Weight loss during frying (frying loss) was expressed as the percentage of weight of raw fish, whereas moisture loss in fried fish was computed as percentage loss of initial weight of raw fish using the following formula:

$$\text{Frying loss (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

where $W_1$ and $W_2$ are the weight of raw fish and fried fish respectively.

$$\text{Moisture loss (\%)} = M_1 - \frac{M_2\,(100-F)}{100}$$

where $M_1$ and $M_2$ are the moisture content (%) of raw fish and fried fish respectively and F is the frying loss (%). Moisture content of the product was estimated by standard hot air oven method. Oil consumption rate during frying was calculated as g of oil consumed to fry 1 kg of fish by using the following formula:

$$\text{Oil consumption rate} = \frac{O_1 - O_2}{W}$$

where $O_1$ and $O_2$ are oil quantity (g) in the frying pan before and after frying of fish respectively and W is the weight (kg) of the raw fish fried.

Proximate composition and salt content were estimated by AOAC (1975) method. Total volatile base nitrogen (TVB-N) and trimethyl amine nitrogen (TMA-N) contents of the samples were determined by Conway's micro diffusion analysis as described by Beatty & Gibbons (1937). Peroxide value (PV) was estimated iodometrically by the method described by Jacobs (1958). Free fatty acid (FFA) content was estimated by improved titrimetric method of Takagi *et al.* (1984). Caloric values of meat were calculated by employing the energy factors, 9.3 for fat and 4.1 for protein (Druve & Ball, 1961).

## Results and Discussion

Fig. 1 represents the pattern of heat penetration during deep fat frying at 120°C and 160°C. The rate of heat penetration to the centre of the fish piece was faster at 160°C than at 120°C. The centre of fish piece attained temperature of 89.3°C in 4 min time at 160°C, whereas at 120°C it took 10 min to attain the same temperature. Similar trend of temperature development in the centre of meat patties during frying was noticed by Dagerskog & Bengtsson (1974). Zaitsev *et al*, (1969) opined that during frying, the temperature in the middle of the fish pieces did not exceed 100°C. In the present study, the centre temperatures of fish piece at the end

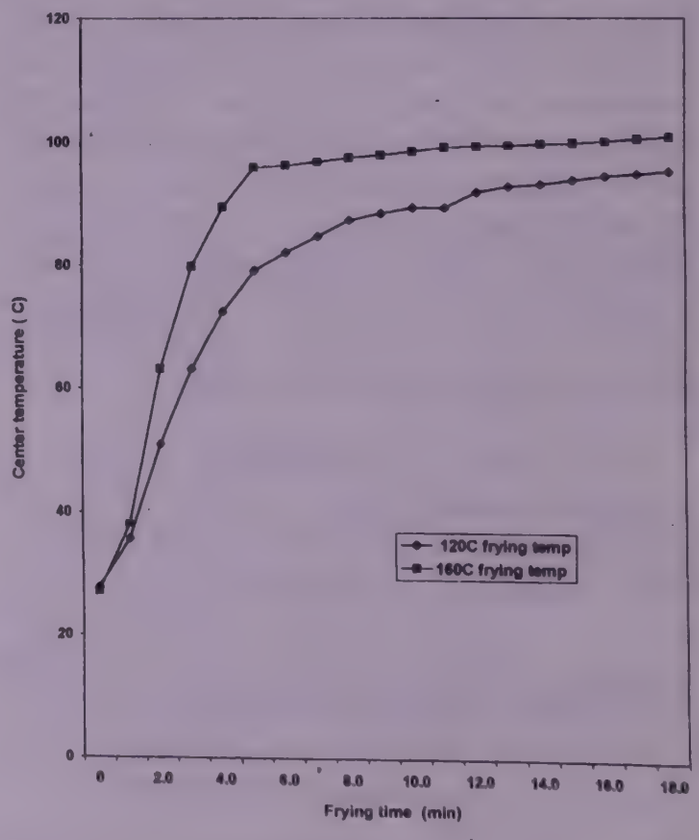


Fig. 1. Rate of heat penetration into the centre of fish piece (5.0 cm long) during frying at 120° and 160°C.

of frying (i.e., after 18 min) were 95.2°C and 100.8°C for frying temperature of 120°C and 160°C respectively.

Fig. 2 depicts the frying loss and corresponding moisture loss under different conditions of time and temperature. Frying loss at a particular temperature increased with increase of frying time. Again, for same frying time, frying losses were more at higher temperatures. At 180°C, the loss was in the range of 27.1 to 43.3% and at 160°C, it varied between 22.1 and 37.1%, depending on the duration of frying. However, the frying losses were comparatively low at 120°C. It varied from 15.3 to 25.1% with variation of frying time from 5 to 20 min. As moisture from the fish flesh was removed during frying, there was weight loss in the fried fish accompanied by a relative increase in the solid content. Moreover, fish also lost weight owing to tiny particles of flesh flaking off during frying. In real sense, frying loss was the difference between the sum of the losses in moisture, fat, flesh and the weight gain due to impregnation of frying oil. According to Zaitsev *et al.* (1969), this loss depends on the oil temperature, frying time, thickness of the pieces and fat content of the fish flesh.

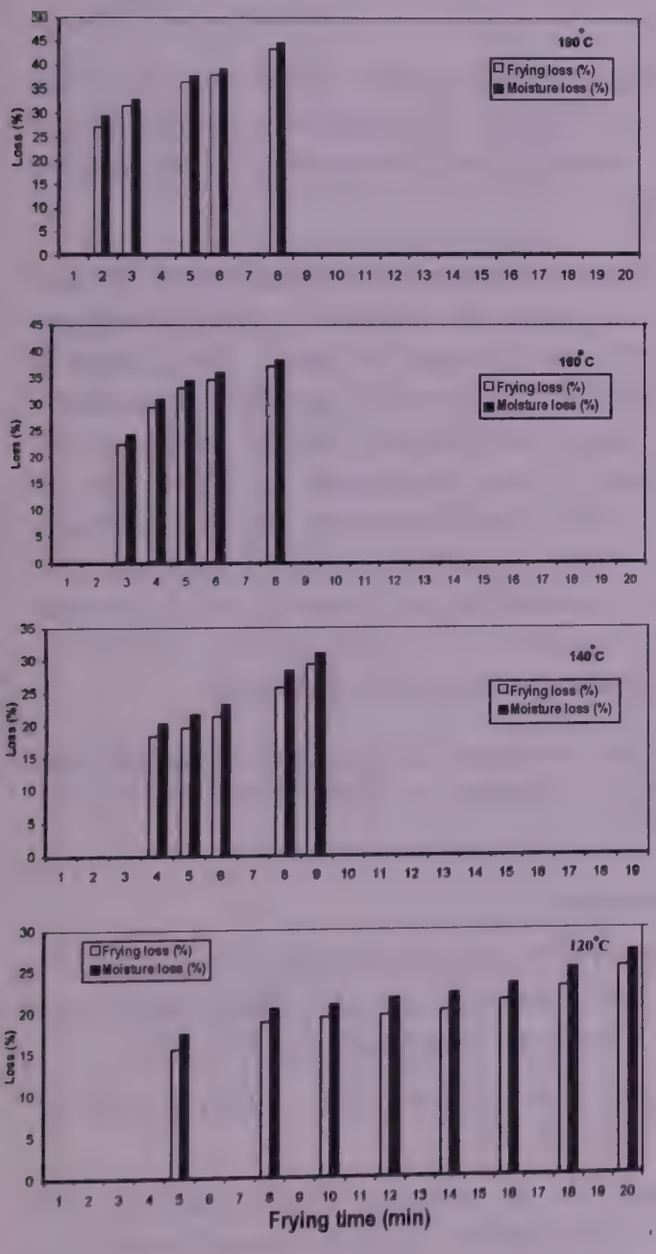


Fig. 2. Frying loss and corresponding moisture loss in fried fish different frying times at 120° and 160°C.

Moisture content of the fried products decreased as the duration of frying increased at a particular temperature. For the same frying time, the moisture content was lower at higher temperatures. The highest moisture content of 66.8% and the lowest moisture content of 52.0% were recorded in the products fried at 120°C for 5 min and at 180°C for 8 min, respectively.

The moisture loss (as percentage loss of initial weight of raw fish) was in the range of 17.3 to 44.4% in this study. The trend was same as that of frying loss. At each frying treatment, the moisture loss was higher than frying loss (Fig. 2). This was due to absorption of some amount of frying oil during frying.

Zaitsev *et al.* (1969) reported that during frying, the flesh of lean fish absorbed 7.0 to 9.0% and that of fatty fish between 3.0 and 5.0% of oil in relation to their flesh weight. In the present study, oil consumption rate during frying at different temperatures was found to vary from 6.45 to 7.05% of the weight of the fish (Table 1). This

Table 1. Oil consumption during frying

| Temperature (°C) | Time (min) | Oil consumption g.kg fish$^{-1}$ |
|---|---|---|
| 180 | 5 | 70.5 |
| 160 | 5 | 67.9 |
| 140 | 10 | 66.4 |
| 120 | 18 | 64.5 |

Table 2. Biochemical characteristics of fresh and fried mackerel

| | Fresh fish (raw) | Fried at 120°C for 18 min | Fried at 140°C for 10 min | Fried at 160°C for 5 min | Fried at 180°C for 5 min |
|---|---|---|---|---|---|
| Moisture (%) | 73.9 | 63.4 | 60.8 | 59.1 | 56.9 |
| Crude protein (%) | 20.4 | 24.3 | 25.7 | 26.5 | 27.4 |
| Crude fat % | 4.4 | 10.9 | 11.6 | 11.7 | 12.5 |
| Total ash (%) | 1.7 | 3.0 | 3.2 | 3.4 | 3.5 |
| Salt (%) | – | 2.3 | 2.4 | 2.5 | 2.6 |
| TVB-N (mg %) | 7.4 | 26.5 | 27.4 | 27.3 | 27.9 |
| TMA-N (mg%) | 1.2 | 4.5 | 4.9 | 5.0 | 5.5 |
| PV (milli equivalents $O_2$/kg of fat) | 1.8 | 6.8 | 6.3 | 6.6 | 6.4 |
| FFA (as % of oleic acid in total fat) | 2.2 | 2.8 | 2.9 | 2.8 | 2.9 |
| Caloric value (kcl. 100g meat$^{-1}$) | 124.4 | 201.0 | 212.8 | 217.1 | 228.6 |

included the amount of oil absorbed into the fish flesh during frying and the wastage of oil while transferring the pieces from the frying pan.

The biochemical changes observed during frying are presented in Table 2. Due to the decrease of moisture content, there was an apparent increase in other components of fried fish (on wet weight basis). A marked increase in the fat content of fried fish was noticed due to absorption of oil by the fish during frying. The fat content on dry weight basis increased from 16.8% in fresh fish to about 30% in the fried samples. The important observation was that the fat content on moisture free basis was almost constant for all the treatments. TVB-N and TMA-N contents also increased in fried fish. Such findings have also been reported earlier in various heat treatments of fishery products (Sundsvold *et al.*, 1971). According to these workers, heat treatments lead to increase in the content of ammonia, trimethyl amine (TMA), dimethyl amine (DMA), mono methyl amine (MMA), etc in fish. There was an increase in PV and FFA values in fried fish. This may be the result of high temperature employed during frying. Similar observations were also found in canned mackerel by George (1987). Increase in the caloric value of the fried fish was due to the relative increase in the solid contents and absorption of fat during frying.

For products where distinct fried flavour and crispness are desired, frying treatment at 160°C for 5 min is ideal. But there is toughening of texture in this treatment. Toughening of texture can be reduced by adopting frying treatment at 120°C for 18 min. Such frying treatment can be effectively used as pre-cooking in place of conventional steam pre-cooking in canning with simultaneous increase in the fat content of fish to give better taste to the product.

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*Fishery Technology*
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# Biogenic Amines in Fresh, Canned and Salt-dried Fishery Products of India

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Biogenic amines viz., putrescine, cadaverine, histamine and tyramine, present in fresh, canned and salt-dried fishery products of Indian origin were analysed by means of TLC – densitometric method. Fresh fish and canned fishery products did not contain appreciable amounts of amines. On the other hand, salt-dried fishery products contained very high levels of biogenic amines. The histamine content in about 17% of the samples was above the maximum allowable limit of 20 mg%. Presence of potentiating amines, viz., putrescine and cadaverine in higher concentrations reflects that poor quality raw material was used for curing process.

**Key words: Biogenic amines, histamine, TLC – densitometry, canned fish, salt dried fish**

Biogenic amines are formed in foods as a result of bacterial decarboxylation of amino acids. They are of importance from the point of view of food poisoning and also as chemical indicators of spoilage. They occur in a wide variety of foods. Large amounts have been reported in aged, fermented and spoiled fish, cheese and meat products (Lakritz *et al.*, 1975; Maga, 1978). Of these, amines present in fish, especially histamine, have been extensively studied.

Earlier, only scombroid fishes were mainly implicated in histamine toxicity. Later studies revealed that non-scombroid fish also could cause histamine poisoning. Other biogenic amines such as cadaverine and putrescine are also equally important as histamine, as they are known as potentiators of histamine toxicity (Taylor & Lieber, 1979; Hui & Taylor, 1983).

Adequate statistics on the incidence of food poisoning caused by histamine and other amines are not available in India due to lack of surveillance programmes. There are a few published reports detailing the histamine content of some fresh and processed fishery products of India (Subburaj *et al.*, 1984; Gopakumar *et al.*, 1988; Chakraborti, 1991, 1993; Vijayan *et al.*, 1994). The above studies have utilized the fluorimetric method of analysis, which is specific only for histamine. No work has been carried out so far on the occurrence of amines other than histamine in the fish and fishery products of India. Therefore, the present study was undertaken to examine the occurrence of biogenic amines in fresh, canned and salt-dried fish of Indian origin.

## Materials and Methods

Fresh fish of commercial importance viz., mackerel, sardine, shrimp, tuna, seerfish and shark were purchased from the retail markets of Mysore. Canned fishery products were obtained from the retail shops of Mysore and Mangalore. Salt-dried fish was procured from Mangalore. All samples were subjected to biogenic amine analysis in triplicate.

Biogenic amine analysis was performed by the TLC-densitometric method following the procedure of Fleischer (1979) with slight modification. Extraction and derivatization

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of amines were similar to the method reported by Rosier & Petegham (1988). Fresh or canned fish (10 g) or salt-dried fish (5 g) were taken and homogenized with 30 ml of 5% hot (80-90°C) trichloroacetic acid(TCA) solution for 2 min and centrifuged at 3000 rpm for 10 min. The supernatant was filtered through Whatman No. 41 filter paper and used for derivatization. Pure biogenic amines viz., putrescine (Put), cadaverine (Cad), histamine (His) and tyramine (Tyr) were obtained from Sigma Chemicals Co., USA. Stock solution was prepared by dissolving accurately 0.20-0.25 g of each amine in 10 ml of 5% TCA. A ten fold dilution was used as the working standard, which was used for derivatization.

One ml of the TCA extract or working standard was taken in a screw cap test tube, to which 1.0 ml of phosphate buffer (pH 9.0, undiluted), a drop of 4 N sodium hydroxide solution and 2.0 ml of dansyl reagent (50 mg of dansyl chloride in 10 ml of acetone) were added. After mixing, the tubes were covered with aluminum foil and left in the incubator at 55°C for 1 h. The tubes were then cooled and stored at 5°C until further analysis.

For fractionation, 10 µl of the dansylated samples were applied and separated on a precoated silica gel GF 254 TLC plate, along with the standard amine mixture. Plates were developed using chloroform: triethylamine (100:25) mixture and the fluorescence was enhanced by spraying with isopropanol:triethanolamine (8:2) mixture. The concentration of the fluorescent amines was measured by the TLC scanning densitometer (Model CS-930, Shimadzu Corporation) under the fluorescence mode (365 nm).

## Results and Discussion

The concentrations of biogenic amines present in fresh fish are given in Table 1. The levels were relatively low in the fresh fish. Fresh fish are reported to have only negligible amounts of biogenic amines (Yamanaka *et al.*, 1986; Gouygou *et al.*, 1992).

Table 1. Biogenic amine concentration in fresh fish sold in the retail market

| Species | Amines mg.100 g$^{-1}$ | | | |
|---|---|---|---|---|
| | PUT | CAD | HIS | TYR |
| Mackerel (*Rastrelliger kanagurta*) | ND | 0.31 | ND | 0.52 |
| " | ND | 0.57 | ND | 0.74 |
| " | ND | 1.35 | ND | 1.23 |
| " | 0.81 | 3.11 | ND | 1.90 |
| " | 0.95 | 2.80 | 0.54 | 2.58 |
| " | 1.25 | 9.42 | 2.34 | 3.04 |
| Sardine (*Sardinella gibbosa*) | ND | 0.49 | ND | 0.29 |
| " | 0.33 | 2.74 | ND | 1.62 |
| " | 1.67 | 2.27 | 1.68 | 1.71 |
| Shrimp (*Parapenaeopsis stylifera*) | 1.14 | ND | ND | 0.88 |
| " | 4.71 | 0.64 | ND | 2.87 |
| Tuna (*Thunnus* sp.) | 0.44 | 1.82 | ND | 1.16 |
| Seerfish (*Scomberomorus* sp.) | 1.42 | 1.77 | ND | 0.94 |
| Shark (*Scoliodon* sp.) | ND | 0.48 | ND | 0.28 |
| Squid (*Loligo* sp.) | 1.82 | ND | ND | ND |

ND - Not detected; All values are average of three determinations

Cadaverine and tyramine were detected in more than 90% of the samples. No histamine was detected in 80% of the samples. Even in the samples where histamine was detected, the level was far below the maximum allowable limit of 20 mg%, prescribed by the EEC (Ababouch, 1991). Earlier, there are reports that histamine contents were more than 20 mg% in the fishes of Indian origin (Subburaj *et al.*, 1984; Nagendra *et al.*, 1988). However, Gopakumar *et al.* (1988) have detected only negligible amounts of histamine (<1 mg%) in the fresh fish which is comparable to the present observation. Therefore, the levels of biogenic amines including histamines in the fresh fish sold in the market were very insignificant and unlikely to cause any toxicity to the consumers.

Biogenic amine concentration in commercial canned fishery products is presented in Table 2. In the canned products, the amines such as putrescine, cadaverine,

Table 2. Biogenic amine concentration in commercial canned fishery products

| Product | Amines mg.100 g$^{-1}$ | | | |
|---|---|---|---|---|
| | PUT | CAD | HIS | TYR |
| Mackerel in brine | ND | 0.58 | ND | ND |
| " | 0.53 | 1.30 | ND | ND |
| " | 4.43 | 5.40 | 0.78 | 0.13 |
| Mackerel in brine and oil | 0.14 | 2.95 | ND | ND |
| Mackerel in curry | ND | 0.14 | ND | ND |
| Sardines natural pack | 0.21 | 2.48 | ND | 0.29 |
| Sardines in oil | ND | 0.17 | ND | ND |
| Sardines in brine | 0.70 | 0.94 | ND | ND |
| " | 0.65 | 0.60 | ND | ND |
| Sardines in brine and oil | 2.24 | 3.22 | 0.54 | 0.15 |
| Yellow fin tuna in oil | ND | 0.12 | ND | ND |
| Little tuna in oil | ND | 0.18 | ND | ND |
| Light meat tuna | 0.86 | 1.56 | ND | ND |
| Seer fish in oil | ND | 0.42 | ND | ND |
| Prawns in curry | 1.71 | 0.21 | ND | 0.34 |
| Chank meat in oil | ND | 0.11 | ND | ND |

ND - Not detected; All values are average of three determinations

histamine and tyramine were detected in negligible amounts. Out of the 16 samples, histamine was detected only in two samples and its concentration was very insignificant (<1 mg%). The concentration of other amines viz., putrescine and cadaverine were slightly higher in the samples where histamine was detected. Canned products analysed did not seem to pose any toxicity problems. Earlier workers have reported high histamine levels in canned fish (Taylor *et al.*, 1978; Kim & Bjeldanes, 1979; Ababouch *et al.*, 1988) but none of the samples analysed during this study had such high levels of histamine.

Data on distribution of the amines in commercial salt-dried fish are presented in Table 3. The values are expressed on fresh weight basis in order to compare the amine levels with the limits prescribed by the regulatory agencies. The salt-dried fish analysed belonged to three classes viz., finfish (Class I), elasmobranchs (Class II) and shellfish (Class III). Under the Class I, two batches of mackerel, sardines and catfish had histamine content ranging from 32 to 53 mg%, which was above the hazard action

Table 3. Biogenic amine concentration in commercial salt-dried fishes

| Product | Amines mg.100 g$^{-1}$ | | | |
|---|---|---|---|---|
| | PUT | CAD | HIS | TYR |
| **I. FIN FISHES** | | | | |
| **Group A (His >20 mg%)** | | | | |
| 1. Mackerel (*Rastrelliger kanagurta*) | | | | |
| a. Batch 1 | 26.44 | 95.59 | 32.10 | 39.84 |
| b. Batch 2 | 18.96 | 67.81 | 46.03 | 24.16 |
| 2. Oil sardine (*Sardinella longiceps*) | | | | |
| a. Batch 1 | 18.07 | 132.44 | 53.06 | 14.69 |
| b. Batch 2 | 10.03 | 77.13 | 35.26 | 9.09 |
| 3. Catfish (*Arius arius*) | 12.70 | 90.58 | 26.34 | 9.65 |
| **Group B (His >10 mg%)** | | | | |
| 1. Mackerel (*Rastrelliger kanagurta*) | 7.61 | 43.90 | 15.58 | 8.58 |
| 2. Clupeids (*Thryssa* sp.) | | | | |
| a. Batch 1 | 30.06 | 243.88 | 14.21 | 16.09 |
| b. Batch 2 | 30.18 | 226.37 | 16.17 | 11.38 |
| 3. Anchovy (*Stolephorus* sp.) | | | | |
| a. Batch 1 | 46.18 | 89.39 | 10.14 | 9.85 |
| b. Batch 2 | 56.08 | 172.22 | 11.59 | 21.37 |
| 4. Lesser sardine (*Sardinopsis* sp.) | 10.91 | 85.66 | 12.58 | 13.23 |
| **Group C (His >1 mg%)** | | | | |
| 1. Carangid (*Caranx* sp.) | | | | |
| a. Batch 1 | 56.95 | 351.18 | 0.72 | 152.16 |
| b. Batch 2 | 26.56 | 206.01 | 0.34 | 39.77 |
| 2. Ribbon fish (*Trichurus* sp.) | 3.37 | 1.33 | 0.41 | 1.55 |
| **Group D (His - not detectable)** | | | | |
| 1. Silver bellies (*Leiognathus* sp.) | | | | |
| a. Batch 1 | 24.18 | 73.95 | ND | 11.49 |
| b. Batch 2 | 21.16 | 90.49 | ND | 14.77 |
| 2. Flat fish (*Cynoglossus* sp.) | | | | |
| a. Batch 1 | 5.97 | 23.64 | ND | 4.80 |
| b. Batch 2 | 8.85 | 29.17 | ND | 4.83 |
| 3. Seer fish (*Scombeormorus* sp.) | 54.68 | 112.80 | ND | 15.42 |
| 4. Threadfin bream (*Nemipterus* sp.) | 10.04 | 38.87 | ND | 20.17 |
| 5. Perch (*Epinephelus* sp.) | 15.31 | 94.62 | ND | 26.02 |
| 6. Pipe fish (*Sigarmus* sp.) | 13.25 | 51.77 | ND | 17.79 |
| 7. Anchovy (*Stolephorus* sp.) | 2.29 | 3.93 | ND | 0.80 |
| **II. ELASMOBRANCHS** | | | | |
| 1. Shark (*Scoliodon* sp.) | | | | |
| a. Batch 1 | 2.46 | 8.95 | ND | 4.57 |
| b. Batch 2 | 2.75 | 15.10 | ND | 7.84 |
| c. Batch 3 | 12.45 | 33.57 | ND | 14.97 |
| 2. Ray (*Raja* sp.) | 11.42 | 62.60 | ND | 9.34 |
| **III. SHELLFISHES** | | | | |
| 1. Shrimp (*Penaeus* sp.) (Whole) | | | | |
| a. Batch 1 | 112.71 | 52.80 | ND | 70.47 |
| b. Batch 2 | 102.55 | 45.32 | ND | 75.32 |
| 2. Shrimp (Peeled deveined) | 8.83 | 2.45 | ND | 5.19 |
| 3. Small shrimp (*Acetes* sp.) | 12.77 | 0.58 | ND | 8.97 |

ND - Not detected; All values are average of three determinations

level of 20 mg% prescribed by the EEC. High levels of cadaverine was also detected in these samples and the cadaverine to histamine ratio was very high (1.5-3.5:1), which is similar to the observation of Klausen & Lund (1986) who have reported that mackerel contains 2-5 times more cadaverine than histamine. Putrescine concentration was found to be lower than histamine. The fishes of clupeids group, lesser sardines, two batches of anchovies and one batch of mackerel contained histamine in the range of 10-17 mg%, which was above permissible level (10 mg%). Among these, the clupeids and anchovies had comparatively higher cadaverine and putrescine concentration than histamine. The fishes that contained histamine, except catfish, mostly belonged to the family Scombridae and Clupeidae, which are often known to be involved in histamine toxicity problems (Taylor, 1986).

Most of the non-scombroid fishes contained no histamine except carangids and ribbon fish, in which negligible amounts of histamine were detected. However, the concentrations of other amines such as putrescine, cadaverine and tyramine were found to be quite high. Wide variations in the concentrations of the different amines were observed among the species and this could be probably due to the differences in the availability of the substrate (amino acids). However, variations observed within the species viz., mackerel and anchovy, perhaps reflect the differences in the initial freshness of the raw material.

In elasmobranch and shellfish (Class II and III), histamine was totally absent, whereas other biogenic amines were detected. Shark and ray had comparatively lower levels of putrescine, cadaverine and tyramine. Shellfish had high levels of putrescine and tyramine than cadaverine. Similar observations have been reported by Meitz & Karmas (1978) and Shakila *et al.* (1996). Presence of lower levels of amines in peeled and deveined shrimps compared to whole shrimps could be partially due to the effect of beheading and deveining process.

Earlier studies reveal that 50% of the salt-dried fish of Indonesian origin had histamine content above 20 mg% (Hanson *et al.*, 1985). However, in India, 20% of the fish was reported to contain histamine exceeding this limit (Chakraborti, 1991). In the present study, only about 17% of the samples contained histamine above hazard action level. Histamine content of salt-dried fish analysed by Chakraborti (1991) varied from 4.1 to 80.6 mg%, which was comparable with the present observations. Biogenic amine profiles of South Asian salt-dried fish showed that the cadaverine content ranged from 66-333 mg%, putrescine from 0-218 mg% and histamine from 0-80 mg% (Wootten *et al.*, 1989), which is more or less similar to the values obtained in the present study.

Therefore, it can be inferred that some of the salt-cured fish sold in Indian markets do have high levels of histamine (>10 mg%) and are likely to cause toxicity to the consumers. The concentrations of other amines such as putrescine and cadaverine were also found to be relatively high in salt-dried products, although histamine levels were very low. This perhaps reflects the poor quality raw material employed for curing process. On the contrary, the fresh and canned fish available in the retail markets contain insignificant levels of amines including histamine and they do not pose any toxicity problems to the consumers.

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*Fishery Technology*
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# Changes in Protein during Drying of Milk Fish (*Chanos chanos*) at 60°C

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Milk fish collected from brackishwater culture ponds was dressed and dried at 60°C for 24 h and biochemical changes taking place during drying were studied. Alpha amino nitrogen (AAN) showed a slight increase but total free amino acids (FFA) showed significant reduction during 24 h drying. The variation in individual free amino acid was found to be different for each amino acid. Salt soluble nitrogen and SH group decreased considerably as a result of drying. Electrophoretic study showed a decrease in the number of high molecular weight and low molecular weight protein fractions, but intermediate molecular weight proteins did not show considerable change.

**Key words: Biochemical changes, fish drying, milk fish, *Chanos chanos***

Considerable quantities of dried fish are consumed in developing countries like India. Natural drying by exposure to sun and wind is widespread and is possibly the first method used for preserving seafoods. This is still applied to a large extent to preserve fish and squid (Sikorski *et al.*, 1995). Conventional air drying at relatively higher temperature is detrimental to fish muscle, because, as a result of evaporation, more moisture and salts are diffused to the surface resulting in increase in salt concentration and changes in pH which affect solubility and water binding properties (Zyas, 1997). Extensive work on biochemical and nutritional changes during heating at higher temperature (100°C and above) has been done by many workers (Sano *et al.*, 1994; Synowiecki & Shahidi, 1991) and only a few reports are available on biochemical and nutritional changes during dehydration (Mao & Sterling, 1970; Raghunath *et al.*, 1995)

Heat treatments bring about complex changes in the muscle proteins. Reduction in solubility due to protein aggregation, mainly by formation of disulfide bonds, isopeptide bonds, etc., is the major consequence of these changes. Different fractions of muscle get denatured at different temperatures, starting from 60°C for myosin to 81°C for actin (Poulter *et al.*, 1985) This study was undertaken to evaluate the biochemical changes during drying of farmed milk fish at 60°C.

## Materials and Methods

The study was carried out using *Chanos chanos* collected live from the culture ponds near Cochin. The fish was iced immediately and transported to the laboratory and drying was carried on the same day. The total length of the fish ranged from 37 to 42 cm and weight from 420 to 430 g. The fish were eviscerated and split open from dorsal side and washed thoroughly to remove blood and visceral parts. They were kept skin side down on perforated aluminum trays and placed in oven preset at 60°C. The temperature was maintained constant throughout 24 h of drying. The samples were drawn at intervals of 0, 2, 4 , 6 ,8 ,12 and 24 h of drying. Skin was removed and meat ground as finely as possible. The samples were then stored in sealed polythene cover at-18°C until analyses were carried out.

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Moisture and total nitrogen were determined according to AOAC (1975). Dyer's buffer extract of the samples was prepared by homogenizing 3 g of accurately weighed sample in 60 ml of pre-cooled Dyer's buffer (5% NaCl buffered with 0.02M $NaHCO_3$) and centrifuging the homogenate (Dyer *et al.*, 1950). Centrifugation was at 10,000 rpm for 20 min at 0°C. The supernatant was used for determination of salt soluble protein (Gornell *et al.*, 1949) and salt soluble nitrogen (SSN) (Dyer *et al.*,1950). The Dyer's extract was diluted to 5mg/ml for electrophoresis, which was done according to Laemmli (1970). Sulfhydril group (SH) was estimated as described by Sedlak & Lindsay (1968). Trichloro acetic acid (TCA) extract was prepared by grinding 10 g of accurately weighed sample with 10% TCA and quantitatively filtering through Whatman filter no.1. The volume was made up to 100 ml. The TCA extract was used to measure α-amino nitrogen (AAN) (EBC, 1975), non-protein nitrogen (NPN) (AOAC, 1975), and total free amino acids (FFA) (Ishida *et al.*, 1981). Total amino acids were estimated by hydrolysis of about 0.5 mg of the fish muscle for 24 h at 110°C in vacuum sealed tubes. The sample was filtered and flash evaporated to remove the acid and then the pH was adjusted to around 2.5. Separation and estimation of amino acids were done by HPLC (Ishida *et al.*, 1981). Tryptophan was determined by colorimetry after alkali hydrolysis (Sastry & Tummuru,1985). All the determinations were carried out in triplicates except amino acids and moisture for which only duplicates were done.

## Result and Discussion

Table 1 gives the changes in moisture, SSN, NPN, AAN, Total FAA, and SH group during drying of *C. chanos* at 60°C. The moisture content came down to 25.8% from 73.6% in 24 h (Table1). The values for NPN and AAN decreased slightly by 2 h of drying and then increased up to the completion of drying. The reduction in NPN and AAN by 2 h may be due to the loss of some of NPN and AAN in the water that oozed out and drained during the initial stages. Some of the soluble components also might have been lost in the exudate water. Protein breakdown on further heating might have caused the increase in NPN and AAN.

The SH group content in the fish muscle decreased during drying at 60°C, retaining only about 23% of the initial level. Raghunath *et al.* (1995) studied the effect of drying of fish at 50, 60, and 70°C on proteins and found that the SH groups registered a regular and sharp decrease with drying except at 50°C where initially an increase was observed. The initial increase found in this case was attributed to the unfolding of protein chains exposing the buried SH groups, which subsequently became oxidized. It was reported that temperatures higher than 50°C are required for oxidative transformation of SH groups to S-S bonds (Opstvedt *et al.*, 1984). Loss in cystiene also can cause reduction in SH groups.

Table 1. Changes in Moisture, SSN, NPN, AAN, Total FAA and SH group during drying of *Chanos chanos* at 60°C

| Parameters | Drying time | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 h | 2 h | 4 h | 6 h | 8 h | 12 h | 24 h |
| Moisture (%) | 73.55 | 70.44 | 66.26 | 62.71 | 54.99 | 48.04 | 25.82 |
| NPN ($mg.g^{-1}$)* | 21.1±0.09 | 16.2±0.12 | 17.94±0.39 | 18.75±0.32 | 19.3±0.10 | 21.24±1.27 | 22.5±0.91 |
| AAN ($mg.g^{-1}$)* | 4.0±0.007 | 3.4±0.01 | 3.5±0.011 | 3.61±0.07 | 3.96±0.003 | 3.82±0.002 | 4.3±0.008 |
| Total FAA ($mg.g^{-1}$)* | 46.7 | 36.43 | 39.97 | 43.15 | 36.47 | 39.39 | 24.11 |
| SSN ($mg.g^{-1}$)* | 115±10.35 | 90.7±9.5 | 75.6±3.78 | 61.58±2.6 | 46.4±1.35 | 44.8±3.58 | 42.3±0.01 |
| SH group ($\mu$ mole.$g^{-1}$)* | 76.1±1.52 | 61.3±0.35 | 53.7±1.14 | 44.6±0.71 | 37.6±3.56 | 20.2±1.01 | 16.8±1.34 |

*On dry weight basis

The heat treatment studies with *Tilapia* and *Siganus* muscles (Poulter *et al.*, 1985) showed that the total extractable protein remained at its initial level until a temperature of 35-40°C was reached, while cod muscle protein began to lose its extractability at temperatures between 25 and 30°C. It was reported that aggregation of cod myosin molecule increased with temperature (35-55°C) and was considerably higher than those for herring at all temperatures (Gill *et al.*, 1992). Salt enhanced aggregation of cod myosin on heating above 50°C. But thermal aggregation of herring myosin showed little dependence on salt concentration. Aggregation affects protein solubility. Thus, the change in protein solubility varies from species to species. Solubility of protein in solvents like water 0.6M NaCl, 1.5M urea, 8M urea and 1% SDS decreased as drying progressed at 50, 60 and 70°C (Raghunath *et al.*, 1995). From the lower solubilisation in water, 0.6 M NaCl and 1.5 M urea it would appear that hydrogen and ionic bonding did not contribute as much towards denaturation by drying, as do hydrophobic bonds, which appeared to play a major role. Formation of covalent disulphide linkages and reaction of ε-$NH_2$ groups of lysine with lipid oxidation products or amide groups (Bjarnason & Carpenter, 1970) could be implicated in these denaturation processes.

Reduction in the salt solubility of protein of *C. chanos* at 60°C proceeded at a faster rate till 8 h of drying and afterwards it was very negligible. But SH groups decreased at a regular rate till the end of drying. The loss of all SH groups may not be due to oxidation of SH to S-S bonds. Destruction of cysteine also leads to loss of reactive SH groups.

Though an increase in AAN was observed, the total free amino acid content decreased (Table 1). This may be due to the breakdown of protein into intermediate weight polypeptides and smaller peptides. The N terminal of these would have answered the ninhydrin reaction for AAN. But since the filtrate was not hydrolysed before the estimation of free amino acids, the amino acids of the peptides were not estimated. Hence the free amino acids registered a decrease in value.

Table 2 shows the changes in the major free amino acids and Table 3 gives the changes in essential amino acids during drying of *C. chanos* at 60°C. As seen from Table 2, the major free amino acids did not show a regular pattern in their changes during drying at 60°C. However, the values of taurine, glutamic acid and lysine were less than the initial value after 24h drying while those of glycine registered an increase and that of alanine did not change. These variations may be attributed mainly to the interactions of amino acids with the other constituents, mainly lipid oxidation products during drying, which results in a reduction in the amino acids content. At the same time some free amino acids may be formed by hydrolysis of peptides and proteins which increases the amino acid content.

Table 2. Changes in the major free amino acids during drying of *Chanos chanos* at 60°C

| Amino acid ($mg.g^{-1}$)* | Drying time | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 h | 2 h | 4 h | 6 h | 8 h | 12 h | 24 h |
| Tau | 6.09 | 6.06 | 5.08 | 5.45 | 6.92 | 8.41 | 5.21 |
| Glu | 0.78 | 0.91 | 1.06 | 0.95 | 1.33 | 1.06 | 0.64 |
| Gly | 1.52 | 1.81 | 1.50 | 1.16 | 1.80 | 2.97 | 1.94 |
| Ala | 0.57 | 0.68 | 0.65 | 0.65 | 0.78 | 0.90 | 0.55 |
| His | 33.47 | 22.17 | 26.84 | 30.73 | 20.31 | 21.1 | 12.22 |
| Lys | 1.13 | 0.95 | 1.00 | 0.88 | 1.05 | 0.67 | 0.52 |

*On dry weight basis

Among essential amino acids, maximum loss was observed in the case of cysteine (35%) followed by lysine (28.4%) and methionine (27.2%) (Table 3). In the present study, about 4% of tryptophan was lost durng drying. Other essential amino acids showed a loss of around 20%. Experiments have shown that a reaction between amide groups and the ε-amino group of lysine in protein can occur at practical drying temperatures. Reaction of the ε-amino group of lysine with degradation products of cysteine is also considered to be partially responsible for the lysine binding in heated protein (Bjarnson & Carpenter, 1970). Methionine, histidine and cysteine are the amino acids most labile to damage by heat and peroxidised lipids (Neilsen *et al.*, 1985).

Dehydration resulted in considerable loss of moisture which could lead to protein denaturation. These changes caused hardening of muscle and significant reduction in extractability. Lipid oxidation products also react with proteins forming stable bonds, which render the protein insoluble. Synowiecki & Shahidi (1991) found a large decrease in solubility of seal meat protein and an increase in their degree of coagulation at temperature ranges from 50 to 75°C. There was 22.07% reduction in SH group as a result of oxidation of SH groups to S-S bonds. Hamm & Hofmann (1965) observed that heating meat to 70°C increased the availability of SH groups as a result of unfolding of protein molecules. In the present study this was not noticed even though the dehydration temperature was 60°C. This may be due to the longer duration of exposure to 60°C so that some of the SH groups would have been oxidized to S-S bonds.

Table 3. Changes in the essential amino acids during the drying of *Chanos chanos* at 60°C

| Amino acid* ($mg.g^{-1}$) | Initial | After 24 h drying | % Loss |
|---|---|---|---|
| Thr | 37.9 | 29.68 | 21.7 |
| Cys | 16.93 | 11.01 | 35.9 |
| Met | 20.76 | 15.12 | 27.2 |
| Val | 41.62 | 32.48 | 21.9 |
| Ile | 37.52 | 28.86 | 23.1 |
| Leu | 59.6 | 46.04 | 22.8 |
| Tyr + Phe | 57.3 | 42.0 | 26.7 |
| His | 69.37 | 55.1 | 20.6 |
| Lys | 54.13 | 38.76 | 28.4 |
| Trp | 11.68 | 11.2 | 4 |

* Dry weight basis

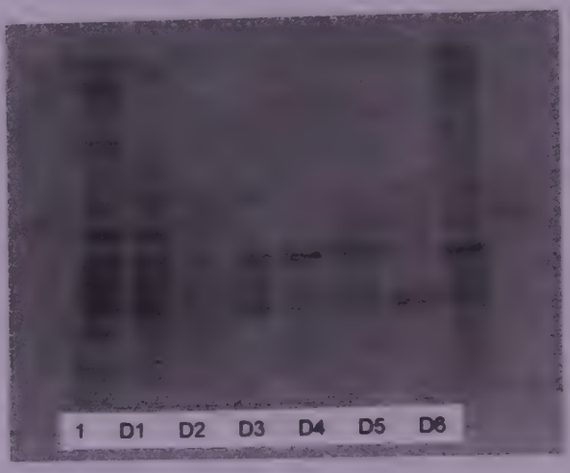


Fig. 1. Electrophoretogram (SDS PAGE) of samples dried at 60°C

Fig. 1 presents the electrophoretogram of protein during drying of *C. chanos* at 60°C. With the increase in drying time, protein bands disappeared gradually. In general, higher molecular weight protein fractions were found to be more sensitive and these disappeared earlier during drying than the lower molecular weight protein bands. Only the medium molecular weight protein bands remained after 4 h of drying which also disappeared slowly. But two of the bands were seen in the 24h dried sample also. It is likely that stainability by coomassie brilliant blue was lost upon denaturation by drying. Poor staining of protein extracted with 8M urea from fish meal has been recorded earlier (Moodie & Eva, 1974). This may also contribute to the non-visibility of the protein bands.

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# Effect of Graded Levels of Dietary Stress Care on Growth, Survival and Body Composition of Common Carp, *Cyprinus carpio*

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'Stress care', a product from Indian Herbs Ltd., was evaluated for its effect on growth of common carp through dietary incorporation. The indoor culture system with aeration and water circulation and without aeration and water circulation were used for the growth study for 60 days. Three levels of stress care at 0.15, 0.50 and 0.75% of the diets were fed to common carp fry. Incorporation of stress care did not produce any beneficial changes in the growth and survival of common carp. However, its effect on common carp under stressful culture conditions needs to be investigated further.

**Key words: Stress care, carp feed, *Cyprinus carpio***

The exotic carp, *Cyprinus carpio* is widely distributed in freshwaters of temperate, sub-tropical and tropical countries. This is cultured widely and is ranked third in terms of aquaculture production (FAO, 1992). India is endowed with vast expanse of inland water resources which are at present not being adequately exploited (Mehboob & Sheri, 1997).

Incorporation of steroid hormones as growth promoters in fish feeds is not encouraged due to health consciousness among consumers which necessitates a search for other growth promoting substances. Evidences indicate that hormone enhances growth by stimulating greater voluntary food intake and substantially improving food conversion (Matty, 1986). Indian Herbs Ltd., Saharanpur, U.P., India have manufactured and released a product called 'stress care' which is known to reduce natural stress in farm animals and poultry, thereby improving growth and survival. It has been claimed that stress care improves glucose metabolism, protein synthesis and corticosteroid sparing effect in poultry (Murthy *et al.*, 1999). The objective of the present study was to test the effect of stress care on the growth, survival and body composition of exotic carp, *C. carpio* in indoor closed water recirculatory system with and without aeration and water circulation.

## Materials and Methods

Indoor closed water recirculatory system consisting of 24 fiber glass tanks of 120 l capacity each and arranged in two tier pattern was used for the study. Waste water from culture tanks was allowed to biofilter tanks, wherein it was filtered biologically in the three tanks which contained graded layers of sand and gravel, oyster shells and clam shells respectively. The filtered water was pumped to an overhead tank of 2000 l capacity, from where water flowed back to the culture tanks by gravity (Murthy, 1977).

Common carp fry (2.36±1.3 g) were acclimatized to the laboratory conditions by feeding a control diet. Fishes were then stocked in the experimental tanks at the rate of 10 per tank in triplicate groups and

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designated as $S_0$, $S_1$, $S_2$ and $S_3$ treatments corresponding to 0, 0.25, 0.50 and 0.75% stress care in the diets. The experiment was carried out in two rearing conditions i.e., with aeration and water circulation and without aeration and water circulation. The test diets (pellets) were prepared using fishmeal, groundnut cake and rice bran as protein sources keeping crude protein level at 30% (Table 1).

Fish were fed to satiation with respective experimental diets in triplicate groups. Leftover feed was siphoned out after allowing one hour feeding time daily and the unconsumed feed was dried and pooled treatment-wise to quantify the actual intake of feed by fish. Each tank was covered with nylon-meshed lid to avoid jumping and escape of fishes. Fortnightly sampling of fish was carried out to record the growth in terms of weight and length. The experiment was conducted for a duration of 60 days.

Water samples drawn from each tank were analysed for various water quality parameters such as pH, dissolved oxygen, free carbon dioxide, total alkalinity and total ammonia following standard methods (APHA, 1998). Water temperature in the culture tanks was also recorded using an ordinary thermometer.

The proximate composition of the experimental diets and carcass composition of fish were determined according to AOAC (1995). Nitrogen-free extract (NFE) was calculated as carbohydrate by the difference method of Hastings (1976). The calorific content was calculated using the physiologi-

Table 1. Ingredient proportion and proximate composition of the test diets

| | Diet | | | |
|---|---|---|---|---|
| | $S_0$ | $S_1$ | $S_2$ | $S_3$ |
| **Ingredient** | | | | |
| Fish meal (%) | 18 | 18 | 18 | 18 |
| Groundnut cake (%) | 44 | 44 | 44 | 44 |
| Rice bran (%) | 22 | 22 | 22 | 22 |
| Tapioca flour (%) | 8 | 8 | 8 | 8 |
| Ragi flour (%) | 6 | 6 | 6 | 6 |
| Vit. and min. premix (%) | 1.5 | 1.5 | 1.5 | 1.5 |
| Common salt (%) | 0.5 | 0.5 | 0.5 | 0.5 |
| Stress care (%) | 0.0 | 0.25 | 0.5 | 0.75 |
| **Proximate composition*** | | | | |
| Moisture (%) | 6.1 (0.15) | 5.6 (0.11) | 6.0 (0.02) | 6.00 (0.04) |
| Crude protein (%) | 29.3 (0.08) | 30.1 (0.14) | 30.0 (0.05) | 30.2 (0.03) |
| Crude fat (%) | 2.7 (0.12) | 2.2 (0.03) | 2.5 (0.06) | 2.4 (0.04) |
| Crude fiber (%) | 3.7 (0.05) | 3.6 (0.04) | 3.8 (0.02) | 3.5 (0.07) |
| Ash (%) | 16.3 (0.15) | 16.1 (0.01) | 16.1 (0.02) | 15.3 (0.06) |
| Nitrogen-free extract (%) | 41.8 | 42.4 | 41.6 | 42.7 |
| Caloric content ($kj.g^{-1}$) | 10.8 | 10.8 | 10.8 | 11.9 |

* Expressed as percentage of dry weight; Figures in parentheses indicate standard errors

Table 2. Water quality parameters recorded in different treatments

| | With aeration and water circulation | | | | Without aeration and water circulation | | | |
|---|---|---|---|---|---|---|---|---|
| | $S_0$ | $S_1$ | $S_2$ | $S_3$ | $S_0$ | $S_1$ | $S_2$ | $S_3$ |
| Temperature (°C) | 27-30 | 27-31 | 27-31 | 28-30 | 28-31 | 28-31 | 27-30 | 27-31 |
| pH | 7-7.8 | 7.6-8.2 | 7.2-7.7 | 6.6-8.3 | 6.8-7.8 | 7.6-8.2 | 6.6-8.3 | 7.0-7.6 |
| Dissolved oxygen ($mg.l^{-1}$) | 6.31-8.31 | 4.34-5.63 | 5.31-6.48 | 5.36-6.37 | 4.59-6.26 | 4.96-6.18 | 4.96-6.31 | 4.34-5.63 |
| Free carbon dioxide ($mg.l^{-1}$) | 1.3-1.8 | 1.3-1.5 | 1.2-1.5 | 1.6-2.3 | 2.1-2.6 | 1.7-2.3 | 1.3-1.5 | 1.2-1.5 |
| Total alkalinity ($mg.l^{-1}$ of $CaCO_3$) | 85.84-96.34 | 83.84-96.34 | 71.84-98.94 | 73.31-86.43 | 98.34-108.34 | 96.36-113.38 | 96.41-118.41 | 108.30-124.89 |

cal values of 5 kcl.g$^{-1}$ for protein and 9 and 4 kcal.g$^{-1}$ for fat and carbohydrate, respectively (Smith, 1975; Hastings, 1975). The growth data obtained after the termination of the experiment was tested using one-way analysis of variance technique (Snedecor & Cochran, 1980).

**Results and Discussion**

The mean and the range of various water quality parameters recorded are presented in Table 2. The details of growth of fish (weight), survival, specific growth rate (SGR), food conversion ratio (FCR) and protein efficiency ratio (PER) are summarized in Table 3. Maximum growth was recorded in control groups of both the systems. In tanks with aeration and water circulation, the growth rate was higher in the group which was not given 'stress care'. The trend was the same in the system without aeration and circulation. The best survival of common carp was observed in system with aeration and circulation. Analysis of carcass composition showed no significant difference in quality of flesh of fish fed different experimental diets (Table 4).

Some of the feed additives and growth promoters like G-probiotic which contains yeast and B-complex vitamins have been used in fish feeds. It was reported that best growth of common carp was induced by 2g.kg$^{-1}$ of G-probiotic in the diet (Kumar, 1994), while in tilapia 7.5g.kg$^{-1}$ of G-probiotic gave best growth (Naik *et al.*, 1999). Stafac-20, which has 2% viriginiamycin as an active ingredient, induced maximum weight gain

Table 3. Weight gain, survival, SGR, FCR and PER of common carp fed graded levels of stress care in two systems

| | With aeration and water circulation | | | | Without aeration and water circulation | | | |
|---|---|---|---|---|---|---|---|---|
| | $S_0$ | $S_1$ | $S_2$ | $S_3$ | $S_0$ | $S_1$ | $S_2$ | $S_3$ |
| Initial weight (g) | 2.43±0.02 | 2.66±0.03 | 2.53±0.01 | 2.67±0.02 | 2.50±0.01 | 2.52±0.01 | 2.63±0.01 | 2.69±0.01 |
| Final weight (g) | 5.31±0.17 | 5.00±0.02 | 4.67±0.09 | 4.82±0.10 | 4.56±0.13 | 4.44±0.09 | 4.16±0.03 | 4.44±0.07 |
| Weight gain (g) | 2.85±0.18 | 2.34±0.04 | 2.14±0.08 | 2.15±0.10 | 2.06±0.12 | 1.93±0.08 | 1.53±0.02 | 1.75±0.06 |
| % weight gain | 118.52 | 87.97 | 84.58 | 80.52 | 82.40 | 76.19 | 58.17 | 65.06 |
| Survival (%) | 63.33±12.02 | 53.33±3.33 | 83.33±6.67 | 60.00±5.77 | 80.00±5.77 | 56.67±3.33 | 66.67±8.82 | 50.00±5.77 |
| SGR | 1.02±0.04 | 0.84±0.02 | 0.82±0.02 | 0.79±0.03 | 0.80±0.04 | 0.76±0.02 | 0.61±0.00 | 0.67±0.10 |
| FCR | 4.47±0.17 | 5.69±0.13 | 5.89±0.25 | 5.94±0.17 | 4.86±0.05 | 5.04±0.27 | 6.18±0.18 | 6.4±0.10 |
| PER | 0.78±0.01 | 0.59±0.01 | 0.56±0.02 | 0.56±0.02 | 0.70±0.00 | 0.66±0.03 | 0.51±0.01 | 0.52±0.01 |

Average of three values with standard error

Table 4. Carcass composition (%) of common carp fed graded levels of stress care

| | With aeration and water circulation | | | | Without aeration and water circulation | | | |
|---|---|---|---|---|---|---|---|---|
| | $S_0$ | $S_1$ | $S_2$ | $S_3$ | $S_0$ | $S_1$ | $S_2$ | $S_3$ |
| Moisture | 79.60 (0.42) | 80.09 (0.93) | 79.10 (0.78) | 79.12 (0.97) | 77.93 (0.34) | 77.78 (0.24) | 77.95 (0.34) | 78.18 (0.16) |
| Protein | 17.26 (0.12) | 16.99 (0.31) | 17.59 (0.23) | 17.70 (0.32) | 16.89 (0.12) | 16.17 (0.21) | 16.17 (0.09) | 15.99 (0.20) |
| Fat | 1.91 (0.04) | 1.86 (0.09) | 1.78 (0.10) | 1.73 (0.02) | 1.18 (0.08) | 1.17 (0.05) | 1.16 (0.01) | 1.06 (0.18) |
| Ash | 1.90 (0.12) | 2.05 (0.09) | 2.15 (0.08) | 2.12 (0.08) | 2.06 (0.04) | 2.10 (0.08) | 2.06 (0.05) | 2.16 (0.04) |

Average of three values (expressed on wet weight basis) with standard error

in catla fry and mahseer fingerlings at 100 ppm level (Kumar, 1994). Incorporation of other feed additives like Aquagran and Nutripro-Aqua of natural origin are reported to stimulate higher growth in common carp (Singh, 1993).

The present study did not indicate any positive effect on the growth, survival or body composition of the common carp due to the incorporation of stress care in the diet. In fact, there was a reduction in weight gain and survival rate due to the incorporation of stress care, under the experimental conditions (Table 3). However, in the present study there were no acute stressful conditions. Hence, further studies are necessary to evaluate the effect of stress care on growth and survival of common carp reared under stressful conditions such as high stocking density.

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*Fishery Technology*
2001, Vol. 38(2) pp : 106 - 109

# Seasonal Variation in Growth and Survival of *Penaeus monodon* Larvae Under Hatchery Conditions

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The present paper deals with various aquatic abiotic parameters which influence the spawning, hatching and larval metamorphosis of *Penaeus monodon* in controlled conditions. Water temperature, salinity and dissolved oxygen as well as general hygienic conditions were found to be the critical factors for the successful gonadal hydration, breeding and survival of young ones of *Penaeus* spp. Optimum ranges of hydrographic parameters were temperature 28-30°C, salinity 28-33 ppt and dissolved oxygen close to saturation. The larvae were fed on diatoms (*Chaetoceros* sp.), *Artemia* cysts and egg custard. The algal culture was maintained in the hatchery itself under conducive conditions. The hygienic conditions of the hatchery were maintained by using chemicals such as chlorine, EDTA and formalin. Antibiotics like oxytetracycline and chloramphenicol were used as prophylactic measures in order to prevent outbreak of diseases and infections. The present experiments conducted in Maharashtra revealed that best results in spawning, larval survival and growth could be obtained during September-October months, when temperature and salinity were in favourable ranges.

**Key words : Water quality, feed management, growth, survival, shrimp farming, *Penaeus monodon*, Maharashtra**

With the rapid expansion of penaeid shrimp farming in many countries, the need for producing large quantities of quality prawn seed under controlled conditions is keenly felt and suitable systems are being developed. According to Silas (1980) and Mohamed (1983), among the 55 species of prawns available in India, eleven species are suitable for farming and among them *Penaeus indicus* and *P. monodon* are widely cultured. However, the hatchery technology developed for these two species in India depends entirely on wild gravid spawners collected from sea by trawl fishing during peak spawning season (Rajyalakshmi, 1998). The results of controlled breeding and larval rearing of penaeid prawns are governed by biological factors like size, age, maturation stage and physicochemical parameters such as temperature, pH, salinity and proper larval feeding. The technique in the seed production of *P. monodon* in controlled conditions involves brood stock rearing, induced maturation, spawning and hatching, live feed culture, larval and post larval rearing and hatchery management. In this paper, an attempt has been made to study the water quality parameters and its influence on seasonal variation in growth and survival of *P. monodon* larvae under hatchery conditions in the north-west coast of India.

## Materials and Methods

The experiments were carried out in a private shrimp hatchery complex in Maharashtra. The water intake system was designed in such a way that as the water passed through a filter bed while pumping, it was chlorinated to 5-10 ppm level and allowed to react for a period of 1-2 h to ensure eradication of all pathogens. The seawater was then recirculated through rapid sand filter. Further, the residual chlorine was chemically neutralized by adding sodium thiosulphate. EDTA (10 ppm)

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was also added to get clean water. It was allowed to settle for an hour before using in the hatchery. Continuous aeration of such treated seawater was done by oil free electric air blower to maintain dissolved oxygen level. Experiments were conducted during monsoon (July-August), post-monsoon (September-October), winter (December-January) and summer (March-April), in order to determine optimum conditions and appropriate seasons for *P. monodon* seed production.

Eight FRP tanks of 250 l capacity each were used for spawning purpose. The prospective breeders were acclimatized to specially treated seawater conditions of the hatchery before transferring into the spawning tank. The broodstock was then treated with 100 ppm formalin for half an hour for disinfection and then transferred to maturation tanks. The males and females were then segregated and males were treated with 20 ppm oxytetracycline or chloramphenicol and kept for half an hour before transferring them into maturation tanks. The females were also transferred to maturation tanks after eye stalk ablation.

Healthy gravid females were dipped in 500 ppm formalin for five minutes, rinsed in holding bath and then transferred to spawning tanks. Ablated females usually spawned within 4 to 5 days and spawning usually took place during 22:30-00:30 h. Spawning tanks with gravid females were treated with 10 ppm EDTA and 4 ppm chloramphenicol. The lights were turned out to maintain darkness and noise was kept at a minimum level to create a conducive environment for spawning. Egg evaluation was carried out in the morning. Total egg count, percentage of fertilization, total nauplii count and percentage of hatching were estimated by sampling.

Eight tanks of 10 t capacity each were used for larval rearing. The larvae were acclimatized by adding water from the larval tank into the acclimation containers for nearly 20 min before introducing the nauplii into the larval tanks. Aeration was provided and the population estimated periodically. The critical physicochemical parameters in the larval rearing tanks were estimated twice a day. Larvae were fed with *Chaetoceros* sp. and *Artemia* cysts. Eight tanks with a volume of 23 $m^3$ each were used for rearing of post-larvae after acclimatization. The physicochemical parameters were recorded and periodic assessment of the population in the tank was carried out. Post-larvae were fed with egg custard and freshly hatched *Artemia* cysts.

Egg custard was given at the rate of 15 g twice a day for PL-8 to PL-10, 20 g twice a day for PL-10 to PL-15 and 25 g five times a day for PL-15 to PL-20. Freshly hatched *Artemia* nauplii was given at the rate of 2 nos.$ml^{-1}$ thrice daily for PL-3 to PL-6, 2 nos.$ml^{-1}$ thrice daily for Pl-7 to PL-12 and 3 nos.$ml^{-1}$ once daily for PL-13 to PL-20.

Parameters such as temperature, pH, salinity and dissolved oxygen were monitored daily and all the parameters were determined as per APHA (1985).

**Results and Discussion**

Seasonal variation in survival of *P. monodon* larvae from nauplii to PL-5 stage, PL-5 to PL-20 stage and nauplii to PL-20 stage are represented in Fig. 1. It was observed that in June the water became very turbid and salinity started decreasing making this period unsuitable for culture operations. However, salinity started increasing in July-August and fluctuated between 12 and 20 ppt while temperature and pH ranges were 28-31°C and 7.4-8.1, respectively. The average survival from nauplii to post-larvae (PL-5) was 54.2% and from PL-5 to PL-20, 45.15%. The average survival rate from nauplii to PL-20 was 23.0%. The higher mortality was due to low salinity during later stages of development of larvae as compared to early stages.

The larvae reared during September-October showed better survival rate from

nauplii to PL-5 stage with 67.52%. As the larval development progressed they exhibited better survival rate with 90.28% from PL-5 to PL-20. The survival rate from nauplii to PL-20 stage was 60.16%. The larvae showed optimum growth and optimum intake of food during the period when salinity ranged from 28 to 33 ppt, temperature varied between 20 and 30°C and pH fluctuated between 7.9 and 8.2.

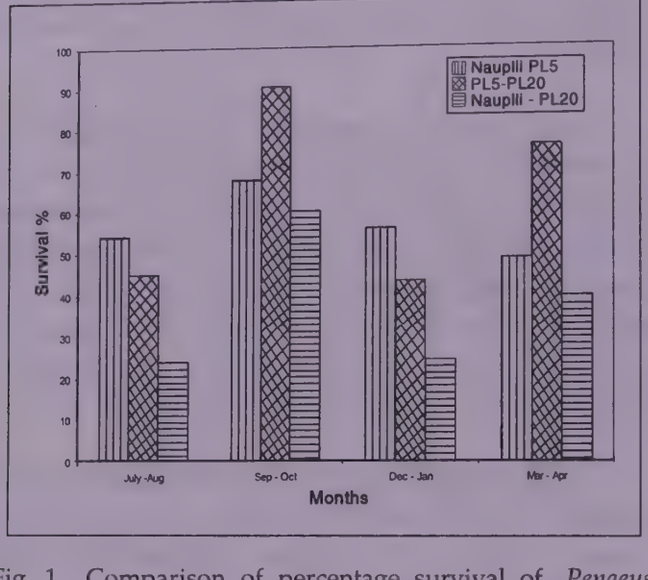


Fig. 1. Comparison of percentage survival of *Penaeus monodon* larvae during different seasons.

During winter months, especially December-January, the temperature decreased and the larvae reared at temperature between 23.2 and 25°C and salinity between 33 and 35 ppt showed retarded growth and reduced feed intake. The survival rate from nauplii to PL-5 was 55.75% while from PL-5 to PL-20 it was 43.12% and in the case of nauplii to PL-20, only 24.25%

During summer months (March-April), the temperature ranged from 32 to 34°C while salinity fluctuated between 34 and 37 ppt and pH was in the range of 7.9-8.4. Under these conditions, the survival rate from nauplii to PL-5 was 45.8% whereas from PL-5 to PL-20 it was 75.81% and from nauplii to PL-20, 39.39%.

The study revealed that the larvae of *P. monodon* survive and grow in hatchery conditions during the months of September-October when critical water parameters such as temperature and salinity were in the range of 28-30°C and 28-33 ppt, respectively. Temperature was a limiting factor in terms of larval survival and influenced their growth rate. The shrimp species are capable of maintaining proper metabolic functions in between the lethal extremes but survival and growth are still affected. Thermal tolerance studies conducted by Motoh (1981) in three different age groups (post-larvae, early juveniles and juveniles) of *P. monodon* revealed that all three age groups could tolerate a low temperature of 10°C for a short period of time. Survival rate was 98% for all three stages studied. However, beyond 39°C there was heavy mortality. The thermal tolerance stated by Motoh (1981) for *P. monodon* post-larvae seems to be extreme. Hudinaga (1942) found that temperature ranging from 24 to 32°C is best suited for development of penaeid larvae. In the nauplius stage of the larvae, the development is mainly controlled by the temperature of the medium and effect of temperature on development is reduced when the larvae start feeding, from potozoea stage onwards (Mohamed, 1983). According to Verghese *et al.* (1975) food intake in *P. monodon* is lower at temperature below 24°C. In the present investigation, it has been observed that temperature ranging from 28 to 30°C is optimum for penaeid larval development which falls within the range reported by Hudinaga (1942).

The salinity tolerance varies from species to species among penaeids, though most species are relatively euryhaline. Spawning and embryonic development of penaeid species represent critical life stages which can be affected by salinity. The experiments conducted by Motoh (1981) showed that the species tolerate very low salinity. Rajyalakshmi & Chandra (1987) reported that *P. monodon* exhibited higher survival rate at 15 ppt. Nevertheless, the survival rate decreased when the rearing time was extended which shows that this species can survive in very low salinity but only for a short period. The results of the present

experiments show that the optimum salinity range for penaeid larvae is between 29 and 33 ppt which is in accordance with Hudinaga (1942) who reported that salinity ranging from 27 to 34 ppt was very conducive for development of penaeid prawns.

Proper growth and development in *Penaeus* spp. require that both salinity and temperature remain within certain limits, which will vary depending on the species. Silas *et al.* (1978) observed that that the temperature of 26.5 to 28.5°C and salinity of 30.2 to 33.5 ppt, were quite appropriate for rearing larvae of *P. monodon*. Mohamed (1983) reported that filtered clean seawater with temperature of 28±2°C and salinity ranging from 28 to 30 ppt were suitable for achieving best results in spawning and greater survival of larvae of penaeid prawns in controlled conditions. In the present investigations it was found that during the months of September-October when temperature and salinity persist in favourable ranges viz., 28 to 30°C and 28 to 33 ppt, respectively, the best results in spawning and larval development of *P. monodon* could be obtained in the hatchery.

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*Fishery Technology*
2001, Vol. 38(2) pp : 110 - 114

# Growth and Feed Utilization Efficiency of *Osteobrama belangeri* Fed Diets Containing Different Levels of Protein

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*Osteobrama belangeri* (Valenciennes), having mean initial body weight of 5.44±0.01g were fed different pelleted diets containing, 20%, 25%, 30%, 40% and 50% crude protein. Fish meal was used as the source of protein. Growth performance and feed utilization efficiency of diets containing 30-40% protein were satisfactory. Best results were observed with diet containing 40% protein, with a daily average weight gain of 0.161 g. There was no improvement in the growth and carcass protein content of fishes fed 50% protein compared to the fish fed 40% protein. The increase in body weight was proportional to the protein content in diet.

**Key words: Fish feed, protein utilization, growth, *Osteobrama belangeri***

Protein is the most expensive component in fish feed. Protein requirements of culturable Asian fishes like carp, tilapia, mullet and milk fish are in the range of 25-30%. Studies on protein requirements of carps have been undertaken by many workers using casein based synthetic diets (Ogino & Saito, 1970, Dabrowski, 1977; Sen *et al.*, 1978; Takeuchi *et al.*, 1979; Singh & Bhanot, 1988). There are also reports on the feeding experiments based on commercial diets (Das & Ray, 1991; Swamy & Mohanty, 1988 and Mohanty *et al.*, 1990) *Osteobrama belangeri* (Valenciennes) is a medium sized carp highly relished by the people of Manipur for its food value. Attempts are being made to culture this fish, which is vanishing from the water bodies of the state. In the present study, growth and dietary protein utilization of *O. belangeri* have been studied by feeding different diets containing different levels of crude protein, with fish meal as the protein source.

## Materials and Methods

Five experimental diets were prepared containing 20, 25, 30, 40 and 50% crude protein, based on fish meal as the protein source (Table 1). Pelleted feeds were prepared, dried in oven and stored in air tight containers.

*O. belangeri* fry of average body weight of 5.44 g were procured from a fish farm. The fishes were acclimatized in a large plastic pool for one week. Ten fishes were distributed in each tank of 30 l capacity, which was connected to a recirculatory system. Each tank was aerated continuously. For each diet, duplicate tanks containing 10 fishes were used. The fishes were starved for 24 h prior to the feeding experiment. The fishes were weighed at the beginning, at every 5 day intervals and at the end of the experiment. All the fishes were fed at a fixed rate of 5.0% body weight per day. The quantity of feed supplied was adjusted according to the body weight. The experiments were continued for 30 days. Faeces were collected from the bottom of the aquaria, dried in an air oven at 105°C and kept in the refrigerator at 4°C, for later analysis.

Experimental diets and fish carcass were analyzed for their proximate composition i.e., moisture, crude protein, crude lipid and ash content (AOAC, 1960). Fibre contents of the feed ingredients and diets

were analyzed by acid based digestion method (AOAC, 1984). Gross energy content of diets was determined using a bomb calorimeter. Water quality parameters were monitored as per APHA (1981).

Protein efficiency ratio (PER) was calculated as described by Zeitoun *et al.* (1973). The maintenance nitrogen metabolism was calculated from the difference in the nitrogen content before and after the experiment with fish fed on a non-protein diet, plus the traces of nitrogen ingested with this diet. For this calculation, it was assumed that trace nitrogen in the non-nitrogen metabolism for *O. belangeri* amounted to 0.5001 mg N per g wet weight per day. The maintenance nitrogen metabolism was calculated according to Dabrowski (1977).

Daily weight gain, initial and final body nitrogen content for productive protein value (PPV), food conversion efficiency and protein efficiency ratio were calculated as follows:

Food conversion ratio (FCR) = Food intake, (dry weight, g) / Body weight gain (g)

Productive protein value (PPV) = Protein gain (g)/Protein intake (g)

Gross conversion efficiency = Growth (dry weight, g)/Feed intake (dry weight, g)

Statistical analysis of the results of feeding trial was made using analysis of variance (ANOVA). Duncan's multiple range test (Duncan, 1955) was used to evaluate the mean difference among individual diets at $p<0.05$ significant level.

## Results and Discussion

During the experiment, there was no mortality of fish. The final weight gain of fish fed on the experimental diets is presented in Table 2 and the changes in weight gain during the experimental period is presented in Fig. 1. The weight gain of fishes increased with the increase of dietary protein level up

Table 1. Proportion of different components and proximate composition, pellet stability and energy content of the experimental diets

| | Diet-1 | Diet-2 | Diet-3 | Diet-4 | Diet-5 | Non-protein diet |
|---|---|---|---|---|---|---|
| Proportion ($g.100g^{-1}$) of different components | | | | | | |
| Fish meal | 20.00 | 27.00 | 40.00 | 55.00 | 70.00 | – |
| Wheat flour | 66.00 | 59.00 | 45.00 | 31.00 | 16.00 | – |
| Groundnut oil (ml) | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| Mineral mixture | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Vitamin mixture | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Starch | – | – | – | – | – | 36.00 |
| Cellulose | – | – | – | – | – | 30.00 |
| Sucrose | – | – | – | – | – | 20.00 |
| Proximate composition ($g.100g^{-1}$) | | | | | | |
| Moisture | 3.80 | 4.60 | 4.62 | 4.72 | 4.78 | 5.85 |
| Crude protein | 20.79 | 24.80 | 32.60 | 41.60 | 50.60 | – |
| Crude lipid | 9.00 | 10.55 | 10.92 | 11.44 | 11.92 | 9.00 |
| Crude fibre | 1.52 | 1.60 | 1.43 | 0.93 | 0.78 | – |
| Ash | 12.22 | 12.02 | 11.24 | 12.24 | 13.40 | 9.80 |
| NFE* | 52.77 | 46.43 | 39.19 | 28.91 | 18.40 | 75.53 |
| Pellet stability | 88.12 | 88.80 | 82.40 | 80.20 | 74.30 | |
| Gross Energy $kcal.100g^{-1}$ | 417.22 | 420.18 | 441.87 | 461.68 | 474.52 | 386.90 |

* NFE - nitrogen free extract

Table 2. Growth efficiency and feed utilization efficiency of *O. belangeri* fed different diets for 30 days

| | Diet-1 | Diet-2 | Diet-3 | Diet-4 | Diet-5 |
|---|---|---|---|---|---|
| Initial weight (g) | $5.44^a$ | $5.45^a$ | $5.43^a$ | $5.44^a$ | $5.46^a$ |
| Final weight (g) | $7.61^a$ | $8.05^a$ | $9.76^b$ | $10.33^c$ | $9.76^b$ |
| Daily weight increment (g/day) | $0.07^a$ | $0.09^a$ | $0.14^b$ | $0.16^c$ | $0.14^b$ |
| Specific growth rate (%) | $1.32^a$ | $1.43^b$ | $2.65^b$ | $2.99^b$ | $2.62^b$ |
| Food conversion ratio (FCR) | $3.85^a$ | $2.98^a$ | $1.16^c$ | $1.09^d$ | $1.58^c$ |
| Protein efficiency ratio (PER) | $4.26^a$ | $3.84^b$ | $2.67^c$ | $2.20^d$ | $1.25^{ac}$ |
| Gross conversion efficiency (%) | $2.26^a$ | $0.37^a$ | $0.74^b$ | $0.92^c$ | $0.63^a$ |
| Productive protein value (PPV) | 0.28 | 2.29 | 4.20 | 8.31 | 2.58 |
| Net protein utilization (NPU) | 29.53 | 29.34 | 21.88 | 17.85 | 14.22 |

Figures with the same superscript do not differ significantly at $p<0.05$

to 40%. Good growth was observed in fish fed 30% and 40% protein diets. The percentage weight gain of the fishes fed different dietary levels was significantly different ($p<0.05$). However, there was decline in the weight gain at higher dietary protein beyond 40% in diet. The highest weight gain per day was obtained in fish fed diet containing 40% protein. The results show the high protein requirement of fish.

The best food conversion ratio (1.09), gross conversion efficiency (0.918) and productive protein value (8.305) were achieved at 40% dietary protein. The protein efficiency ratio (PER) increased with protein content of the diet, up to 40%, but declined thereafter. The Net Protein Utilization (NPU) values ranged between 14-30% (Table 2) and the relationship between NPU and the dietary protein level is presented in Fig. 2.

The carcass composition of fish fed on different experimental diets is presented in Table 3. Protein content of the body increased with increase in the dietary protein level and the difference between groups was statistically significant ($p<0.05$). Highest protein content was found in fish given diets containing 41.6% protein. Dabrowski (1977) had reported increase in both body protein and fat with the increase of protein level of the diet. Cowey *et al.* (1972) also has reported similar findings. However, protein content was lower in fish fed on diet containing 50% protein. There was no significant difference between groups in respect of lipid, ash and water contents of the muscle tissue.

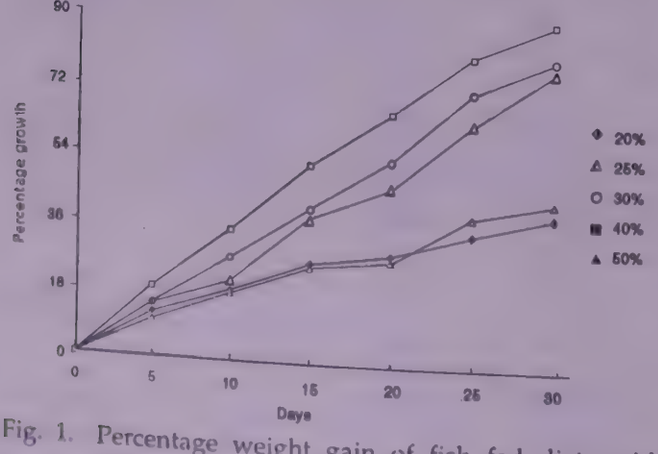


Fig. 1. Percentage weight gain of fish fed diets with different levels of protein

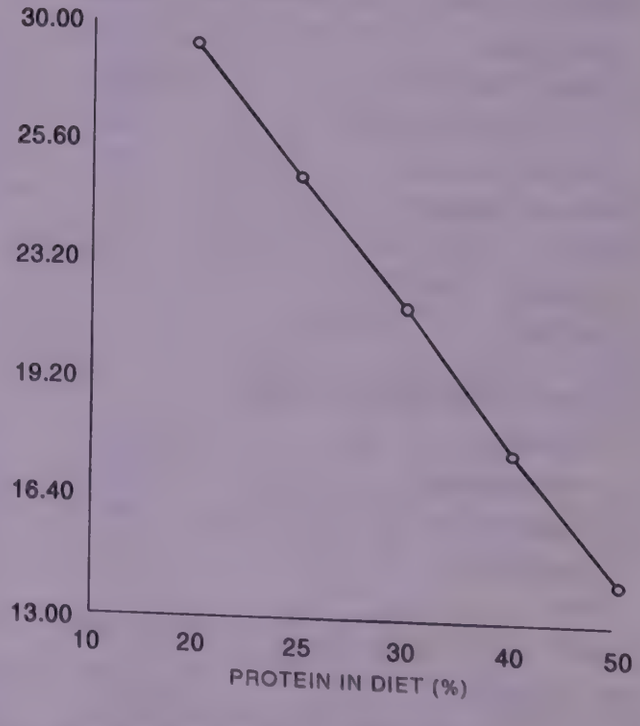


Fig. 2. Relationship between NPU and dietary protein level.

Table 3. Gross body composition of experimental fish at the beginning and end of the experiment (Values are expressed as % wet weight)

| | Initial | Diet-1 | Diet-2 | Diet-3 | Diet-4 | Diet-5 |
|---|---|---|---|---|---|---|
| Moisture | 79.02±1.10 | 78.48[a] | 78.27[a] | 77.37[a] | 76.50[a] | 76.84[a] |
| Crude protein | 12.15±0.31 | 13.81[a] | 13.84[a] | 14.01[b] | 15.67[c] | 14.22[d] |
| Crude lipid | 2.50±0.01 | 2.80[a] | 2.30[a] | 2.43[a] | 2.50[a] | 2.32[a] |
| Ash | 6.05±0.01 | 5.29[a] | 5.01[a] | 5.27[a] | 5.28[a] | 5.32[a] |

Figures with the same superscript are not significant at $p<0.05$

At low protein diets (20-30%), the demand for protein is more for tissue building and repair and nitrogen metabolism, while in higher protein diet (50% crude protein), excess of protein is catabolised to provide energy for growth, thus depressing the protein conversion efficiency (Lee & Putnam, 1973). The negative effect of higher dietary protein levels on growth was also observed in plaice (Cowey *et al.*, 1972). Similar results were obtained in the present investigation also where the growth rate of *O. belangeri* came down at 50% dietary protein.

It has been established that a reduction of dietary energy utilization for normal growth may occur due to extra energy expenditure toward deamination and excretion of excess amounts of amino acids. Various authors have stated that essential amino acids supplied in excess of the optimum requirement may not necessarily enhance protein utilization of fish (Halver, 1957; Mertz, 1972). The optimum growth of fish is attained only if the diets contain sufficient nutrients in proper ratio (Cowey & Sergent, 1979). Dietary protein with proper amino acid balance and density is more important and protein level in diet can be reduced when such balanced diets are provided (Mertz, 1972).

The computed values for food conversion efficiency of *O. belangeri* in the present study indicated maximum utilization of diet at 40% dietary protein, with a decline on either side of the optimum level. Protein efficiency ratio increased progressively up to 40%. The significant fall in PER beyond the optimum level in *O. belangeri* was similar to the results obtained for plaice (Cowey *et al.*, 1972). The productive protein value also was highest at this level of protein. Hence it may be concluded that diet with 40% protein is best for rearing *O. belangeri*.

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# Optimization of Energy to Protein Ratio in Feed for *Labeo rohita* Fingerlings

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Ten semi-purified diets with two levels of dietary protein (32 and 41%) having five energy levels each (324, 341, 364, 384 and 407 kcal.100g$^{-1}$) were formulated and fed to *Labeo rohita* fingerlings for a period of 45 days. Factorial analysis of variance indicated that although weight gain, food conversion efficiency and protein utilization were significantly affected by dietary energy and protein levels, the energy and protein conversion efficiencies were not influenced by dietary energy and protein interaction. The best growth and food conversion ratio (FCR) were obtained with an average of 379.72 kcal.100g$^{-1}$ at 41% protein diet (P/E 107.87 and E/P 9.29), while maximum protein utilization and conversion occurred with similar energy levels (383 kcal.100g$^{-1}$) but in low protein (32%) diet. Although dietary energy influenced the body constituents of fish, the influence of protein was not significant. The results indicated that with increased allowance of energy, more protein was utilized for tissue building and enhancement of growth.

**Key words: Protein-energy ratio, optimum growth, dietary energy, dietary protein, *Labeo rohita***

To make aquaculture economically viable and environmentally sustainable, it is necessary to reduce the proportion of protein components in the diet, without affecting growth of fishes. Higher levels of protein in the fish diet increase the cost of feed as well as deteriorate the water quality through excessive excretion of nitrogenous ($NH_3$) wastes. Cowey (1978) observed that unless sufficient energy is provided, the quality and quantity of dietary protein cannot contribute to protein synthesis to the full extent. Excess of dietary protein is wasteful and creates stress in the animal while excess energy means the production of more fatty fish (Das *et al.*, 1991). Attempts to reduce the amount of protein in fish diet was confined mainly to trout, channel catfish and common carp (Lee & Putnam, 1973; Garling & Wilson, 1976; Takeuchi *et al.*, 1979). Better utilization of dietary protein for growth had been observed when sufficient energy from non-protein sources like carbohydrate, lipid, etc. was available (Schwarz *et al.*, 1983; De Silva *et al.*, 1991; El-sayed & Teshima,1992, Hassan, 1993). Information on the effect of the relationship between dietary energy and protein on growth performance of fishes is still not complete.

The protein requirement of *Labeo rohita*, which is an important species in polyculture practices, is reported to be high (40-50%) (Khan, 1991; De Silva & Gunasekara, 1991; Hassan *et al.*, 1995; Hassan & Jafri, 1996). Apart from the above accounts, there is very little information on the dietary energy-protein balance in carps, especially in rohu fingerlings. Therefore, an attempt has been made to investigate dietary energy and protein interaction and their influence on growth, conversion efficiency and body composition with a view to optimize energy to protein ratio in *L. rohita* fingerlings.

## Materials and Methods

Using dextrin and casein as major components, 10 types of semi-purified diets were formulated containing 32 and 41% crude protein and each was tested at five

different levels of energy (324.34±2.96; 340.87±1.99; 383.85±5.29; 406.48±3.60 kcal.100g$^{-1}$) in 2x5 factorial design (Table 1). α-cellulose and carboxymethyl cellulose were used as fillers and binders. Corn oil and cod liver oil were used as lipid sources. All the ingredients were purchased from Welcome Pharmaceuticals and Sarabhai Chemicals, Baroda, India and were mixed with diet at different concentrations, following the method of Hassan *et al.* (1995). Metabolisable energy equivalents 3.5, 4.5 and 8.5 kcal.g$^{-1}$ for carbohydrates, protein and lipid respectively, were employed for calculating dietary energy levels (Jauncey, 1982).

Rohu fingerlings (3.65±0.26 g) were brought to the laboratory and acclimatized for a period of 15 days in circular cement tanks (200 l capacity). The temperature (28±1°C), pH (7.2 to 7.5), dissolved oxygen (5-7 mg.l$^{-1}$) and photo period (12D:12L) were maintained throughout the experimental period. During the acclimatization period, the fish were fed on commercial carp diets (40% protein).

Fifty fishes of same size were recruited from the stock and divided into ten batches, each consisting of five fish and introduced into circular plastic aquaria (size: 60x75 cm diameter and 75 cm height) connected with PVC tubes with a flow through system having a flow rate of 4 l.h$^{-1}$. Triplicates were maintained for each diet. Fish were fed on the respective feed twice a day (09.00 and 18.00 h) at a rate of 5% of body weight (Haniffa *et al.*, 1987). The feeding trial was conducted for 49 days. Unconsumed feed was collected using a fine sieve after 2 h of feeding and dried at 60°C. Faecal matter was siphoned out every morning before feeding. After the feeding trial, the final weight of the fish was recorded, sacrificed and dried at 80°C and dry weight noted. Samples from each diet were taken and analysed for proximate composition and gross energy. Crude protein was determined by micro kjeldahl method (Nx6.25), while lipid was quantified with petroleum ether using soxhlet extraction technique. Ash content was determined by burning the sample in a muffle furnace at 600°C, for 5 h. Moisture was calculated after fish was dried at 100°C for 24 h.

All data were analysed using one-way ANOVA and the treatment of means were compared using Duncan's new multiple range test (Duncan, 1955). Polynomial regression (2$^{nd}$ order) was employed (Snedecor & Cochran, 1969) to study the relationship between dietary levels of protein and lipid and energy. The variations in the carcass components were calculated through correlation coefficient analyses (Zar, 1984).

The growth performance of fish was evaluated by calculating the relative growth rate (RGR), feed conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER), protein productivity value (PPV) and energy retention efficiency (ERE) (Hassan & Jafri, 1996).

## Results and Discussion

Both dietary energy and protein significantly affected the growth, FCR and PER (Table 2) in *L. rohita* but the interaction was not found to be significant ($p>0.05$). The maximum growth of rohu fingerlings occurred at 41% protein level, which agrees with the protein requirement value reported by Khan (1991), Hassan *et al.* (1995) and Hassan & Jafri (1996) for *C. mrigala* fingerlings through a dose response study. A lower weight gain was noticed at a low energy diet which may be due to insufficient energy consumption. Fixed ration level (5% of body weight) might have restricted the fish from consuming more food to compensate for insufficient energy supply from the low energy diet and as a result, the dietary protein was presumably catabolised to meet its requirements for energy rather than growth. Increase in the growth with increasing levels of dietary protein, within isocaloric diets suggested that an E/P ratio of 9.29 is sufficient for optimum growth of the fish. A

Table 1. Percentage composition of ingredients and proximate composition of experimental diets

| | 32% protein level | | | | | 41% protein level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Ingredients** | | | | | | | | | | |
| Dextrin | 20 | 18 | 18 | 18 | 18 | 14 | 14 | 12 | 12 | 12 |
| Casein (Vitamin free – 92% CP) | 32 | 32 | 32 | 32 | 32 | 42 | 42 | 42 | 42 | 42 |
| Gelatin | 8 | 8 | 8 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| α-cellulose | 28.2 | 26 | 21.09 | 16.16 | 14.19 | 20.20 | 18 | 15.09 | 12.16 | 10.19 |
| Cod liver oil | 3.33 | 4.62 | 5.29 | 6.47 | 6.72 | 3.33 | 4.62 | 5.29 | 6.47 | 6.72 |
| Corn oil | 3.47 | 4.38 | 8.62 | 10.37 | 12.09 | 3.47 | 4.38 | 8.62 | 10.37 | 12.09 |
| Carboxy methyl cellulose | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Vitamin and mineral mix | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Proximate composition** | | | | | | | | | | |
| Crude protein (%) | 31.82 | 31:94 | 32.09 | 32.18 | 31.87 | 40.87 | 40.92 | 40.13 | 40.87 | 40.93 |
| Crude fat (%) | 7.84 | 9.48 | 14.74 | 18.39 | 21.35 | 7.9 | 9.73 | 15.46 | 19.82 | 22.68 |
| Carbohydrate (%) | 43.84 | 41.76 | 36.35 | 31.85 | 26.43 | 27.49 | 25.17 | 21.39 | 17.84 | 14.58 |
| Metabolisable energy (Kca/100g$^{-1}$) | 326.43 | 340.5 | 362.85 | 386.85 | 409.09 | 322.25 | 341.20 | 365.67 | 379.72 | 403.87 |
| E/P | 10.42 | 10.9 | 11.31 | 12.02 | 12.84 | 8.11 | 9.21 | 9.24 | 9.29 | 9.87 |
| P/E | 95.95 | 91.64 | 88.44 | 83.18 | 77.78 | 123.39 | 108.53 | 108.53 | 107.76 | 101.34 |

similar but slightly low value of E/P ratio (8.93) was found to be optimum for *C. mrigala* (Hassan, 1993; Hassan *et al.*, 1995). This result confirms the growth accelerating effect of dietary energy intake up to a certain level with balanced combination of protein and energy intake (Table 1). Analysis of FCR value clearly indicated that both protein and energy of the diet influenced feed conversion of *L. rohita* fingerlings. The increase in weight gain and feeding efficiency up to a certain level of dietary energy has been reported by earlier workers (Takeuchi *et al.*, 1979; Shiau & Huang, 1990; De Silva *et al.*, 1991; Hassan *et al.*, 1995). The low feed conversion and growth rate of rohu fed on high energy diet could be due to poor feed consumption or uptake of high energy diet (Page & Andrews, 1973) or hindrance of digestion and absorption by other dietary nutrients (fat content) present in the diet (Dupree *et al.*, 1979).

The quadratic pattern in relation to SGR to dietary energy revealed that, after a maximum gain at an average of 383 kcal.100g$^{-1}$, a fall in the growth rate was noticed with increase in dietary energy uptake (Fig.1). However, a better growth was observed with increase in the dietary protein levels of the isocaloric diets. Among the isocaloric diets tested, rohu fingerlings fed on 41% protein diet showed low FCR.

The PER also showed a similar trend in relation to energy content. It decreased with dietary protein when isocaloric diets were compared. The value on PER and PPV clearly indicated the influence of dietary energy and protein content on the protein utilization of the fish. The change in the pattern of PER and PPV in relation of dietary energy levels agrees with the observation of

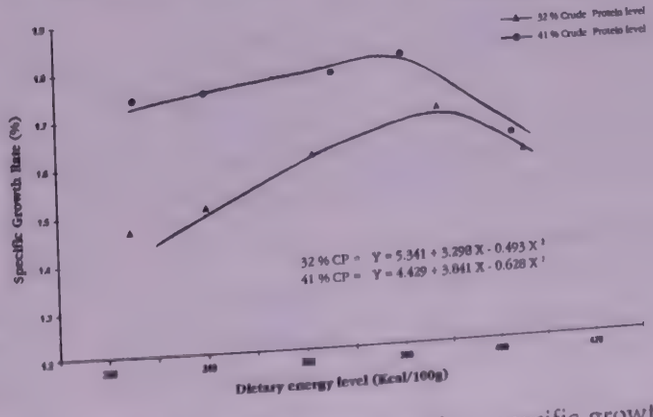
32 % Crude Protein level
41 % Crude Protein level
Specific Growth Rate (%)
32 % CP = Y = 5.341 + 3.298 X - 0.493 X²
41 % CP = Y = 4.429 + 3.041 X - 0.628 X²
Dietary energy level (Kcal/100g)

Fig. 1. Effect of dietary energy level on specific growth rate of *L. rohita* fed on diets containing different levels of protein.

Table 2. Effect of two series of diets on the growth performance of *Labeo rohita*

| | 32% protein level | | | | | 41% protein level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Initial weight (g) | 3.46±0.06 | 3.56±0.01 | 3.58±0.06 | 3.65±0.08 | 3.74±0.07 | 3.66±0.02 | 3.72±0.02 | 3.78±0.09 | 3.86±0.02 | 3.83±0.05 |
| Final weight (g) | 6.33±0.09 | 6.62±0.02 | 6.68±0.11 | 7.30±0.06 | 6.92±0.02 | 7.45±0.02 | 7.57±0.06 | 7.68±0.12 | 8.06±0.02 | 7.40±0.07 |
| Growth (g) | 2.88±0.01 | 3.05±0.02 | 3.26±0.07 | 3.61±0.03 | 3.19±0.01 | 3.79±0.02 | 3.85±0.06 | 3.90±0.11 | 4.20±0.06 | 3.57±0.07 |
| RGR (%) | 83.3±0.42$^{a}$ | 85.75±0.78$^{a}$ | 91.16±1.57$^{a}$ | 96.83±1.47$^{b}$ | 85.28±0.54$^{a}$ | 103.75±0.36$^{b}$ | 103.63±0.36$^{b}$ | 105.64±0.35$^{b}$ | 108.71±0.69$^{b}$ | 93.10±1.90$^{a}$ |
| SGR (%) | 1.48±0.04$^{a}$ | 1.51±0.02$^{a}$ | 1.62±0.02$^{a}$ | 1.69±0.02$^{b}$ | 1.59±0.15$^{a}$ | 1.73±0.05$^{b}$ | 1.73±0.02$^{b}$ | 1.74±0.04$^{b}$ | 1.80±0.04$^{b}$ | 1.61±0.03$^{a}$ |
| PCR | 3.47±0.51$^{b}$ | 3.37±0.25$^{b}$ | 3.25±0.07$^{b}$ | 3.06±0.08$^{a}$ | 3.21±0.06$^{b}$ | 3.01±0.11$^{a}$ | 2.76±0.6$^{a}$ | 2.74±0.08$^{a}$ | 2.56±0.04$^{a}$ | 2.94±0.05$^{a}$ |
| PER | 0.77±0.09$^{a}$ | 0.87±0.09$^{b}$ | 0.90±0.09$^{b}$ | 1.03±0.07$^{b}$ | 0.94±0.4$^{b}$ | 0.73±0.04$^{b}$ | 0.79±0.21$^{a}$ | 0.88±0.01$^{b}$ | 0.95±0.02$^{b}$ | 0.76±0.03$^{a}$ |
| PPV | 18.68±0.87$^{b}$ | 14.70±0.72$^{a}$ | 13.52±0.17$^{a}$ | 12.59±0.23$^{a}$ | 12.35±0.48$^{a}$ | 15.49±0.42$^{b}$ | 14.73±0.16$^{b}$ | 12.62±0.08$^{a}$ | 11.66±0.07$^{a}$ | 10.61±0.07$^{a}$ |
| ERE | 13.59±0.13$^{a}$ | 15.00±0.72$^{a}$ | 17.74±0.34$^{b}$ | 20.08±0.32$^{b}$ | 18.34±0.48$^{b}$ | 16.23±0.03$^{a}$ | 17.65±0.13$^{a}$ | 18.64±0.11$^{b}$ | 21.62±0.14$^{b}$ | 19.49±0.15$^{b}$ |
| Survival (%) | 96 | 93 | 93 | 95 | 100 | 100 | 100 | 97 | 96 | 94 |

Figures in each row having the same superscript were not significantly different

El-Sayed & Teshima (1992) in Nile tilapia and Hassan *et al.* (1995) in *C. mrigala*. Increased PER with decreasing level of dietary protein was reported by Daniels & Robinson (1986) and Parazo (1990) in *Sciaenops ocellatus* and *Siganus guttatus* whereas an inverse relationship between PPV and dietary protein was reported by Millikin (1983) on striped bass. The observation on PPV suggests that incorporation of energy in the diet beyond an average of 383 kcal.100g$^{-1}$ is unproductive and wasteful in the case of rohu fingerlings.

In terms of protein utilization and protein retention, the energy contribution from lipid source (36%) to the total average dietary energy of 383 kcal.100g$^{-1}$ revealed a beneficial effect of dietary lipid. The same trend was noticed in *C. carpio* which was efficient in utilizing high levels of dietary lipids (Jauncey, 1982). A sparing effect of 18% dietary lipid was found to influence the growth of tilapia (De Silva *et al.*, 1990). *C. mrigala* was also found to utilize higher dietary energy from dietary lipid source (Hassan *et al.*, 1995). The energy conversion efficiency (ECE) and protein production value (PPV) were influenced by dietary energy and protein and their interaction was found significant ($p<0.05$). ECE was found directly related to protein level in the diets whereas PPV was inversely related to protein and showed a significant difference ($p<0.05$) up to an average of 383 kcal.100g$^{-1}$ of energy

Table 3. Carcass composition of *Labeo rohita* fingerlings fed experimental diets

| Feed types | Moisture (%) | Protein (%) | Fat (%) | Ash (%) |
|---|---|---|---|---|
| 32% protein level | | | | |
| 1 | 77.14±0.75$^{a}$ | 57.44±0.75$^{c}$ | 16.68±0.10$^{a}$ | 12.85±0.14$^{b}$ |
| 2 | 74.26±0.65$^{ad}$ | 53.48±0.94$^{a}$ | 17.81±0.03$^{a}$ | 11.44±0.06$^{a}$ |
| 3 | 73.79±0.13$^{ad}$ | 53.02±0.54$^{a}$ | 18.79±0.13$^{b}$ | 10.93±0.09$^{a}$ |
| 4 | 73.52±0.31$^{ad}$ | 52.69±0.04$^{a}$ | 21.63±0.14$^{b}$ | 10.45±0.43$^{a}$ |
| 5 | 72.94±0.21$^{c}$ | 51.78±0.11$^{a}$ | 24.61±0.09$^{bc}$ | 9.47±0.10$^{a}$ |
| 41% protein level | | | | |
| 6 | 77.59±0.25$^{a}$ | 57.72±0.19$^{c}$ | 18.28±0.04$^{b}$ | 13.57±0.12$^{b}$ |
| 7 | 76.79±0.19$^{ab}$ | 55.33±0.12$^{b}$ | 19.59±0.16$^{b}$ | 12.91±0.04$^{b}$ |
| 8 | 76.24±0.13$^{b}$ | 54.66±0.79$^{b}$ | 21.98±0.12$^{b}$ | 12.15±0.06$^{b}$ |
| 9 | 75.69±0.15$^{b}$ | 53.92±0.06$^{a}$ | 23.56±0.06$^{b}$ | 11.51±0.06$^{b}$ |
| 10 | 74.86±0.11$^{b}$ | 52.80±0.45$^{a}$ | 28.84±0.11$^{c}$ | 10.90±0.05$^{a}$ |

Figures in each column having the same superscript were not significantly different

at both the protein levels. The interaction of dietary energy and protein appears to influence the energy conversion in *L. rohita*. Increase in energy level beyond 383 kcal. 100 $g^{-1}$ in both the dietary protein levels did not seem to exert a positive influence on energy utilization or growth. So this energy level may be considered to be the optimum for *L. rohita* fingerlings. Earlier works of Lee & Putnam (1973), Cowey (1979) and Hassan *et al.* (1995) support this assumption that surplus protein is used as energy, leading to fat deposition and addition of calorific value of flesh.

The carcass composition (Table 3) showed that the moisture content of the fish was much reduced in animals fed with 32% than 41% protein diets. ANOVA test showed a significant ($p<0.05$) reduction of carcass moisture at both dietary protein levels with increase in energy content. This is similar to the findings in *Ictalurus punctatus* (Garling & Wilson, 1976), hybrid tilapia (*O. niloticus* x *O. aureus*) (Shiau & Huang, 1990), *Cyprinus carpio* (Zeitler *et al.*, 1984) and *C. mrigala* (Hassan *et al.*, 1995). The other body constituents also were significantly affected by dietary energy levels rather than dietary protein.

The whole body protein was negatively correlated to the increase of dietary protein but a positive correlation was reported by De Silva (1991), Hassan *et al.* (1995) Austreng & Refsite (1979) and Millikin (1983). At both the protein levels, the whole body fat showed a significant increase ($p<0.05$) with dietary energy. Positive relationship between whole body lipid with increase of dietary energy was well documented by Watanabe (1982) in rainbow trout. The inverse relationship of body protein with dietary energy might not be due to decreased absolute level of protein but due to the relatively lower level of protein in relation to elevated lipid levels.

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*Fishery Technology*
2001, Vol. 38(2) pp : 121 - 124

# Stability in Water and Sinking Rate of Pelleted Feeds Formulated from Locally Available Ingredients

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Formulations of nutritionally balanced and cost effective feeds for fish and shellfish is of paramount importance in boosting production through aquaculture. Locally available feed ingredients were used for the preparation of pelleted feeds. Water stability and sinking rate of the feed were studied for various durations. The study revealed that stability of the feed reduced while sinking rate increased after 6 months of storage period.

**Key words: Sinking rate, pelleted feed, carps, freshwater prawn**

In aquaculture, feed represents a major input, comprising up to 50% of the total production cost (Naik & Murthy, 1999). Most of the artificial feeds do not meet the protein requirement of different species under culture conditions (Pandey *et al.*, 1992). The advantages of pelleted feed are well known. Though fish culture is an age-old practice in India, the artificial feed used is mostly a mixture of rice bran and groundnut oil cake, which is nutritionally unbalanced (Varghese *et al.*, 1976). Under these circumstances, there is an urgent need for formulation of nutritionally balanced and cost effective diets using locally available ingredients. The pelletisation process is an important criterion to be considered while manufacturing aqua-feed (Mac Grath, 1976). Fish nutritionists have been much preoccupied with physiological aspects of diet evaluation. The present study deals with the wet durability and sinking rate of the pelleted feed prepared for feeding carps and freshwater prawn in grow-out farming.

## Materials and Methods

Various feed ingredients (rice bran, groundnut oil cake, tapioca flour and vitamin mineral premix) used for the preparation of the pelleted feeds were procured from local market and soya flour was supplied by Soya Good Rich (P) Ltd., Shimoga. The ingredient proportion and their protein contribution is presented in Table 1. Two types of pelleted feeds were formulated namely feed A and B with varying proportions of the ingredients. Groundnut oil cake was finely powdered and all other ingredients were then individually sieved through ISI standard mesh No.1 to get particles of uniform size.

Required quantities of the various ingredients (Table 1) were then kneaded well by hand with just sufficient water to obtain a soft consistency (1:0.8, feed to water by weight). The dough so obtained was cooked under steam in a pressure cooker at 105°C for 30 min following the method of Jayaram & Shetty (1981). The cooked dough was then cooled to room temperature by spreading in an enamel tray and vitamin and mineral premix was added and blended. The dough was thoroughly mixed again and extruded through a pelletizer having 2 mm die. The pellets were dried in a hot air oven at 60°C overnight or till the moisture content was reduced to <10%. Both the feeds were packed separately in high-density polythene bags and stored at ambient temperature.

* Corresponding author

The experimental diets prepared were evaluated for their keeping quality. The water stability of the two formulated feeds was determined initially and after storage for six months by wet durability test over a period of 7 h as described by Hastings (1964). The sinking rate of pellets was also estimated in an aquarium tank measuring 1.25x0.5x0.5 m, soon after preparation and after 6 months of storage. Uniform sized pellets (1 cm) were gently dropped into the tank and time taken by the pellets to traverse the depth of the water column was noted with a stopwatch. The average time taken by each type of pellet was calculated separately and sinking rate of pellets was expressed as $cm.s^{-1}$.

## Results and Discussion

The feeds prepared had a protein content of 35%. (Table 1). The data on water stability and sinking rate of the two pelleted feeds recorded initially and after six months of storage are presented in Table 2. Feed B exhibited higher water stability (98.65%) compared to feed A (90.17%). As far as sinking rate was concerned, feed A showed better sinking ability than feed B.

According to Hastings (1976), a 1:1 ratio by weight of ingredient mixture to water would give a proper consistency to the dough. But in the present study, this ratio was 1:0.8 for both feeds in order to achieve the desired consistency. Jayaram & Shetty (1981), Das *et al.* (1994) and Jayadevi & Vishwanath (2000) have studied the optimum requirements of water in the formulation of feed. Cooking of ingredients had been found to be advantageous in terms of destruction of pathogenic bacteria and improvement of nutritional quality (Lovell, 1976). One of the most important requirements of feed is that it should remain intact without losing any nutrients for a specified period after it is placed in water. Carps and prawn being slow feeders, require feeds which remain stable in water without much

Table 1. Proportion of ingredients and their protein contribution in the formulated feeds (%)

| Ingredient | Feed A | | Feed B | |
|---|---|---|---|---|
| | Proportion | Protein contribution | Proportion | Protein contribution |
| Fish meal | 25.0 | 15.1 | 12.5 | 7.6 |
| Soya flour | 25.0 | 10.3 | 37.5 | 15.5 |
| Groundnut oil cake | 20.0 | 7.3 | 28.8 | 10.5 |
| Rice bran | 18.0 | 2.0 | 11.0 | 1.2 |
| Tapioca flour | 10.0 | 0.3 | 8.2 | 0.2 |
| Vitamin mineral premix* | 2.0 | – | 2.0 | – |
| Total | 100.0 | 35.0 | 100.0 | 35.0 |

* Supplied by Sarabhai Chemicals, Wadi Wadi, Baroda

Table 2. Moisture content, water stability and sinking rate of the formulated feeds (mean±SE)

| Feed | Moisture | Water stability % | | | | Sinking rate ($cm.s^{-1}$) |
|---|---|---|---|---|---|---|
| | | Period of immersion (h) | | | | |
| | | 1 | 2 | 5 | 7 | |
| Fresh | | | | | | |
| A | 10.4±0.2 | 90.2±0.08 | 89.7±0.23 | 87.2±0.1 | 85.3±0.2 | 6.2±0.12 |
| B | 9.6±0.16 | 98.7±0.29 | 96.4±0.24 | 91.6±0.18 | 87.5±0.1 | 5.4±0.15 |
| After 6 months of storage | | | | | | |
| A | 12.2±0.36 | 89.6±0.2 | 84.4±0.08 | 85.6±0.23 | 84.53±0.27 | 8.4±0.27 |
| B | 11.8±0.17 | 97.1±0.05 | 94.6±0.17 | 88.4±0.16 | 85.5±0.45 | 7.7±0.16 |

disintegration for at least one hour. The importance of high water stability of pelleted feeds in prawn nutrition was also highlighted by NRC (Anon, 1977). Therefore stability of the pellets in water is an important criterion in assessing their efficiency. The stability of the pellets is influenced by different factors like feed composition, nature of ingredients, type of processing and moisture content (Hastings, 1971). The degree of stability of feeds is dependent on the extent of gelatinisation during steam conditioning (Stivers, 1970). According to Hastings (1971), the low concentration of gelatinisable matter in pelleted feeds decreases their stability. Lim & Dominy (1990) reported that water stability of pellet was inversely related to the level of soybean meal. In the present investigation, there was a slight increase in stability with the increasing level of soya flour in the diet. This could be attributed to the fact that soybean meal is rich in structural high molecular weight carbohydrates, viz., cellulose, hemicellulose and pectins. But it usually contains less than 1% starch (Snyder & Kown, 1987).

The stability of the pelleted feeds decreased when tested after 6 months of storage (Table 2). Ravishankar (1983) and Shyama (1987) have reported that increase in the moisture content of the feed can affect the stability of the feeds in water. It was observed in this study that there was an increase in the moisture content of the pellets during storage and the decrease in the stability of stored samples may be due to the higher moisture level.

In addition to the stability of the feed, sinking rate of the pellets was also determined and is presented in Table 2. The feed employed in the culture system should preferably sink rapidly and be stable for long duration to enable maximum utilization by the culture species. External mastication, exposure to water currents and aeration systems can hasten pellet disintegration and result in loss of nutrients (Anon, 1977). However, in the present study, the sinking rate of the pellets increased following storage and was inversely proportional to the moisture content of the feed as reported by Ravishankar (1983) and Monteiro (1994).

Of the two feeds, feed B had better stability in water and higher sinking rate compared to feed A. This indicates that substituting the costlier fish meal by the cheaper protein source, soya flour, in the preparation of pelleted feed yields a product with better stability and sinking characteristics.

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# Training Needs of Shrimp Farmers – An Assessment

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Thirty shrimp farmers were interviewed in Nagapattinam coastal district of Tamil Nadu, India to assess their training needs. Personal profile of the farmers was found to be of high level and their relationship with training needs was not significant. The farmers desired to acquire necessary knowledge and skills to deal effectively with disease menace, seed quality, pond management and recent developments in aquaculture for sustainable shrimp production. Transfer of technology and human resource development programmes of the research organization and extension activities of the State fisheries departments may be intensified incorporating these training needs.

**Keywords: Human resource development, training need assessment, technology transfer, shrimp farming**

Human resource development (HRD) is an indispensable part of extension science and is widely regarded as the single most important resource for speedier socio-economic development (World Bank, 1990). Training is a planned and systematic effort to increase knowledge, improve skills, inculcate appropriate attitudes and develop favourable other attributes to enable an individual to do better in his/her job (Misra, 1990). Training helps not only in honing one's skills but also in updating them. Training need assessment is a process of systematic identification of the needs and problems of a specific target group (Smith *et al.*, 1991). Shrimp farming involves high social, economic and environmental stakes and identifying training needs of shrimp farmers at regular intervals followed by appropriate training could be a viable strategy for the sustained growth of this industry. Keeping this in mind, a study was taken up to assess the training needs of shrimp farmers and suggest means for extension.

## Materials and Methods

The investigation was taken up during February 2000, in Nagapattinam district of Tamil Nadu, which is one of the shrimp farming "hot spots" along the east coast of India. A sample of 30 farmers was selected from three creeks in the study area, viz., Vettal creek, Kaduviar creek and Vellaiyar creek. In order to identify the training needs, the entire shrimp farming operation was divided into 10 sub items as suggested by subject matter specialists. These were site selection and farm construction, pond preparation, seed selection and stocking, feed management, pond management, health management, advances in shrimp farming, sustainable shrimp farming, group farming/ cooperative farming and socio-economics and environmental consequences of shrimp farming.

The training needs were assessed by means of a three-point continuum namely 'most needed', 'somewhat needed' and 'least needed' which were assigned scores of 3, 2 and 1, respectively (Sailaja & Reddy, 1999). A training need index was calculated using actual/maximum possible score method based on adding the scores expressed by the farmer on all items. Ranking was given to training needs based on their total individual scores. Socio-personal, socio-economic and socio-psychological variables, fourteen in number, (Table 1) were studied by using appropriate tools (Kumaran, 1998)

to understand the profile of farmers and their relationship towards training needs. Data were collected by employing a well-structured and pre-tested interview schedule. Frequency distribution, mean, percentage, correlation analysis and t tests were used for analysis and interpretation.

## Results and Discussion

The findings of the study regarding the profile of the farmers are presented in Table 1. It maybe seen that most of the respondents were less than 50 years of age and had collegiate and above level of educational status. The innovative nature of the enterprise could have attracted young and highly educated people. Majority of the respondents (66.67%) had other occupations in addition to shrimp farming and this may be due to the risk and cost intensive nature of shrimp enterprise. About 80% of respondents had farm size of less than 4 ha. The experience of the respondents varied from 2 to 9 years. Almost all the farmers were practising modified extensive farming of *Penaeus monodon* with 5-6 nos. of post larvae per $m^2$ The annual income of the respondents varied from Rs. 30,000 to 5,00,000 because of their differential occupations. Majority of the respondents (60%) availed credit from banks or private money lenders.

Farmers were aware of extension agencies of concerned organizations. However, majority of them had limited contacts with these agencies. Most of the respondents had medium to high degree of mass media exposure. They were of the opinion that aquacultural programmes were very rare in mass media channels. The respondents were found to be high risk takers (80%), exhibited high degree of scientific orientation (70%) and economic motivation (73.33%). Fellow farmers and feed company representatives were the prime sources of information. Meeran & Jayaseelan (1999), while studying socio-personal, socio-economic and socio-psychological profile of shrimp farmers, reported similar findings.

Table 1. Socio-personal profile of shrimp farmers

| Variables | % of farmers (N=30) |
|---|---|
| **Age** | |
| Less than 50 years | 56.67 |
| 50 years & above | 43.33 |
| **Education** | |
| SSLC/H.Sc. | 33.33 |
| Graduates and above | 66.67 |
| **Occupation** | |
| Aquaculture alone | 33.33 |
| Aquaculture + others | 66.67 |
| **Farm size** | |
| Up to 4 ha | 80.00 |
| Above 4 ha | 20.00 |
| **Farming experience** | |
| Up to 5 years | 56.67 |
| Above 5 years | 43.33 |
| **Type of farming** | |
| Modified extensive type | 93.33 |
| **Annual income** | |
| Less than Rs. 25,000 | 93.33 |
| Above Rs. 25,000 | 6.67 |
| **Credit orientation** | |
| Obtained | 60.00 |
| Not obtained | 40.00 |
| **Extension agency contact** | |
| Low | 40.00 |
| Medium | 40.00 |
| High | 20.00 |
| **Mass media exposure** | |
| Low | 13.33 |
| Medium | 60.00 |
| High | 26.67 |
| **Social participation** | |
| Low | 6.67 |
| Medium | 33.33 |
| High | 60.00 |
| **Risk orientation** | |
| Low | 3.33 |
| Medium | 16.67 |
| High | 80.00 |
| **Scientific orientation** | |
| Low | 10.00 |
| Medium | 20.00 |
| High | 70.00 |
| **Economic motivation** | |
| Low | 6.67 |
| Medium | 20.00 |
| High | 73.33 |

The training needs of shrimp farmers in the order of ranking are presented in Table 2. It was noticed that 90% of the respondents expressed their need to have training on health management. This is because diseases

Table 2. Training needs of shrimp farmers

| Training needs | % of farmers (N=30) | Rank |
|---|---|---|
| Health management | 90.00 | 1 |
| Recent advances in shrimp farming | 74.44 | 2 |
| Pond management (soil, water quality, etc.) | 65.56 | 3 |
| Seed selection and stocking | 63.33 | 4 |
| Pond preparation | 61.11 | 5 |
| Feed management | 52.21 | 6 |
| Sustainable shrimp farming | 48.89 | 7 |
| Group farming/cooperative farming | 48.89 | 8 |
| Site selection and farm construction | 45.56 | 9 |
| Socio-economics, environmental consequences of shrimp farming | 40.00 | 10 |

are the major threat to shrimp farming. The farmers showed keen interest to know the ways to prevent the occurrence of diseases, easy ways to detect them and methods of effective disease control. About three-fourth of the respondents (74.44%) desired to be informed of recent advances in shrimp farming. About 65% of respondents opined that they needed training on pond management, especially regarding soil and water quality conditions, water exchange, application of probiotics, etc. This may be due to their understanding that optimum soil and water conditions are critical for a successful crop.

Majority of the respondents (63.33%) wanted training in identification of quality seed, seed testing and stocking. Farmers were of the view that getting good quality seed is one of the major constraints. The need for acquiring the knowledge in identification and detection of healthy seed was also felt and expressed. More than half of the respondents (61.11%) desired to have training in pond preparation, especially on application of correct dose of inputs, proper blooming, optimum levels of various parameters, etc. About half of the respondents (52.22%) desired to have training in feed management – identification of good quality feeds, recommended feeding schedule and method of application. The major expenditure in shrimp farming is on feed and the farmers are for its judicious use.

Nearly half of the respondents required training on sustainable shrimp production including every step from site selection to post harvest management. Equal percentage of farmers were of the view that shrimp farmers need to be educated on group farming. About half of the respondents expressed their desire to be educated on proper site selection and appropriate method of farm construction. Significant number of farmers desired to have training on the social, economic and environmental consequences of shrimp farming, so that they can be prudent enough to make efforts to minimize the unfavourable consequences.

To study the nature of relationship between the personal attributes of shrimp farmers and their training needs, a correlation analysis was carried out. The results of correlation analysis (Table 3) have clearly shown that there is no significant relationship between them. Fourteen variables were taken for analysis and none of the attributes was significantly related. Further, the attributes like age, education and farm size

Table 3. Relationship between personal attributes and training needs of shrimp farmers

| Personal attributes | Corr. Coeff. (r) |
|---|---|
| Age | –0.264 NS |
| Education | –0.029 NS |
| Occupation | 0.168 NS |
| Farm size | –0.059 NS |
| Farming experience | 0.022 NS |
| Type of farming | 0.101 NS |
| Credit orientation | 0.062 NS |
| Annual income | 0.012 NS |
| Mass media exposure | 0.109 NS |
| Extension agency contact | 0.136 NS |
| Social participation | 0.284 NS |
| Risk orientation | 0.044 NS |
| Scientific orientation | 0.160 NS |
| Economic motivation | 0.316 NS |

NS = Not significant at 0.05 level

were negatively related. It was proved that shrimp farmers, irrespective of their social, economic and psychological standing, were eager to acquire necessary knowledge and skills for obtaining successful crops on a long-term sustainable basis.

It could be inferred from the above findings that most of the shrimp farmers opted for training in one or the other aspect of shrimp farming. Health management, seed quality detection, pond management and recent advances in aquaculture were the major training needs identified. It is suggested that training camps should be organized on the identified aspects at field level with appropriate training modules in simple local language, on learning by doing basis. The transfer of technology and human resources development programmes of the research organizations, promotional agencies and extension activities of the State fisheries departments may be intensified incorporating these training needs.

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*Fishery Technology*
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# Marketing Efficiency of Fresh Fish Trade in Cochin and Veraval

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Price spread is an important index of marketing efficiency. This study reports the price spread between landing centres, wholesale and retail markets in Cochin (Kerala) and Veraval (Gujarat) for important varieties of fish. The price spread is very high both in wholesale and retail markets. While in wholesale market the price spread ranged from 1.11% to 46%, it was as high as 471% in the retail market at Veraval and 1410% at Cochin. The range of price spread was found to be very high during the periods of low price and high catch, and low during high price and low catch season. The benefit of high price spread accrue to the middlemen, depriving both the consumer and the fishermen of a fair price.

**Key words: Price spread, marketing channel, marketing intermediaries, landing centre, wholesale market, retail market**

The price spread, measured as the difference between the price paid by the consumer and the price received by the fishermen, is an important index of marketing efficiency as well as the fairness with which the market treats the consumer and the producer. An efficient and fair market is characterized by a quantum of price spread that is equivalent to the marketing costs including the cost of storage, transport, display, handling, package, the opportunity cost of marketing functionaries and the transaction capital. Studies have been carried out on the marketing efficiency in fish trade in Uttar Pradesh (Katiha & Chandra, 1990) and Tamil Nadu (Sathiadas & Panikkar, 1988). The study of marketing margins is of special significance in fisheries for the reason that fish prices fluctuate far more drastically than the price of manufactured goods. While most manufactured consumer goods show a steady upward movement, fish prices show a cyclical upward movement. The short period cycles of very high and low price for fish allow enough room for marketing intermediaries to exploit both the fishermen and the consumer, rendering the market inefficient and unfair. Hence, a systematic investigation of this aspect is of importance for the producers as well as the consumers.

## Materials and Methods

With a view to estimate the price spread in fish markets of Cochin (Kerala) and Veraval (Gujarat), primary data were collected from landing centres, wholesale and retail markets for major species of fish marketed in these localities. Data were collected over a period of two years from 1998 to 1999, covering all the seasons. The data collection was carried out twice a week from landing centers at Veraval and Cochin Fisheries Harbour and the corresponding retail markets at Cochin and Veraval. In addition, the major beach landing centres of Cochin such as Kamalakadavu and Vypin were covered once a week. Data for the first and last days of the week were not included, so as to avoid abnormalities in price formation.

Price spread reported in the study covered important table varieties of fish such as sardine, mackerel, seer fish, pomfret, threadfin bream, shark, tuna, thread fish, wolf herring, perch and catfish.

## Results and Discussion

The first stage of fish marketing is the bulk landing of fish in landing centres.

Landing centres vary considerably in terms of marketing facilities available. In Cochin, fish landing centres such as Kamalakadavu and Fort Cochin have no landing facilities at all. The catch is auctioned as the craft touches the shores, after the price fixation onboard. The catch is secured in baskets (50-70 kg) by the wholesaler, who in turn auctions the fish in lots of baskets. In Fisheries Harbour, the practice is same but the landing facilities and handling facilities are better resulting in least harm to the quality of the fish. From the wholesaler onwards, marketing channel takes diverse direction and means. There are wholesale dealers who secure fairly large quantities of fish and take them to distant markets in mini-trucks, selling all along the way. Next come moped-borne vendors, who also have an extended reach to interior markets. Most common vendors are, however, cycle-borne vendors who are the main channel connecting wholesalers and consumers. The established urban retail markets in Cochin have direct linkage between wholesalers and consumers. The oldest channel of fisherwomen vendors continue to thrive in spite of the multiplicity of marketing functionaries (Fig.1).

The main channel of fish trade in Veraval is the landing centre – wholesaler – retailer – consumer chain. Door-to-door vending is not common in Veraval.

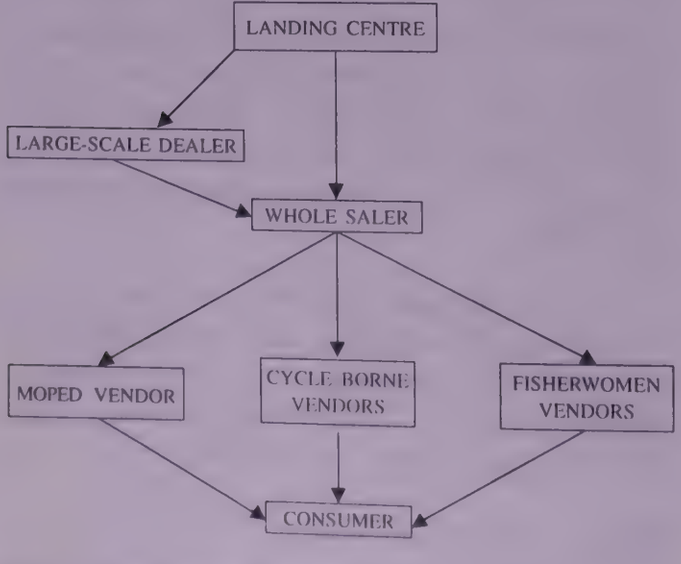


Fig. 1. Fish trade channels operating at Veraval and Cochin

Modal prices for different varieties of fish in the retail markets at Veraval and Cochin during different months are given in Table 1. It may be observed that every variety of fish showed a very high range of fluctuation in price. The percentage difference between the lowest price and the highest price was maximum in the case of seer fish (166.67%) in Cochin and white pomfret (500%) in Veraval (Table 1). These price fluctuations were generally induced by seasonal differences in landings. Marketing

Table 1. Retail price movements in Cochin and Veraval

| Variety | Rs. $kg^{-1}$ | | Month |
|---|---|---|---|
| ***Cochin*** | | | |
| Sardine | Low | 20 | November-December |
| | High | 30 | March-October |
| Mackerel | Low | 30 | May |
| | High | 45 | December |
| Seer fish | Low | 60 | March |
| | High | 160 | June |
| Pomfret | Low | 60 | September |
| | High | 70 | November |
| Threadfin bream | Low | 20 | August |
| | High | 30 | September |
| ***Veraval*** | | | |
| Ribbon fish | Low | 15 | September |
| | High | 30 | February |
| Croaker | Low | 10 | December |
| | High | 30 | March-June |
| Pony fish | Low | 20 | March |
| | High | 50 | September |
| Spotted bearded-croaker | Low | 25 | October |
| | High | 60 | September |
| Tuna | Low | 20 | Nov., February, April |
| | High | 50 | March |
| Shark | Low | 15 | February |
| | High | 40 | July |
| Wolf herring | Low | 15 | December, February |
| | High | 50 | April |
| Thread fish | Low | 15 | March |
| | High | 40 | April, June |
| Mackerel | Low | 8 | April |
| | High | 30 | May |
| Perch | Low | 20 | December |
| | High | 50 | February, March |
| White pomfret | Low | 50 | January, February |
| | High | 300 | March, April |
| Seer fish | Low | 30 | Nov., Jan., Feb. |
| | High | 60 | Jan., April, October |
| Catfish | Low | 15 | October, January |
| | High | 40 | August |

intermediaries usually tend to narrow down the price fluctuations. However, this role is largely ineffective on account of the extremely perishable nature of fish and fish products and the market functionaries are generally inclined to take advantage of these fluctuations for their own profit rather than stabilising the prices.

At Cochin, wholesalers from different markets procure their stock from landing centre by participating in the bids. The quantity unsold at the landing centre is transported to major fish markets like Kottayam, Aluva and Changanassery and sold to wholesalers through open auction. At Veraval, the first stage transaction takes place at Bhidiya where the landing centre as well as the wholesale market are located. The wholesalers supply the fish to smaller vendors in small lots. The later transactions usually take place in established markets. Sometimes, vendors pool their resources and join the auction to lift the stock at wholesale prices from the large traders directly. The retail markets at Veraval are situated at Bhidiya and Kharakua.

In Table 2, wholesale price is given as a percentage of landing price for different varieties of fish. Even in this initial phase of transaction in the landing centre, there was considerable price spread between landing price and wholesale price. The percentage increase in prices for different species ranged from 1.11 to 45.83%.

Cost of marketing being a fixed element per kg of fish marketed, the higher percentage of marketing margin indicates more than normal share of total revenue accruing to the marketing functionaries. The margin of abnormal profit generated in the first phase of marketing goes to the large traders who lift the supply from fishermen and sell to the wholesalers, hardly keeping the stock for more than a couple of hours, unless the heavy stock forces them to store the fish. Marketing margin is generally high during high catch and lower price. This phenomenon is explained by the fact that there is an upper price limit beyond which the consumer will not purchase fish. Therefore, at times of low catch and high price, marketing margin is kept low to make fish saleable. When prices come down drastically at landing centre, the reduction is not proportionately passed on to the succeeding stages of marketing. The market functionar-

Table 2. Price spread between landing centre and wholesale market in Veraval

| Variety | Low* | High* | Range of price spread* |
|---|---|---|---|
| Ribbon fish | 105.00 | 111.11 | 5.00-11.11 |
| Croaker | 103.57 | 112.50 | 3.57-12.50 |
| Pony fish | 101.11 | 111.11 | 1.11-11.11 |
| Spotted bearded croaker | 101.23 | 104.84 | 1.23-4.84 |
| Shark | 102.27 | 107.69 | 2.27-7.69 |
| Tuna | 102.78 | 105.56 | 2.78-5.56 |
| Wolf herring | 106.67 | 109.09 | 6.67-9.09 |
| Thread fish | 103.12 | 145.83 | 3.12-45.83 |
| Mackerel | 103.12 | 132.14 | 3.12-32.14 |
| Perch | 104.17 | 105.00 | 4.17-5.00 |
| White pomfret | 101.86 | 106.86 | 1.86-6.86 |
| Seer fish | 104.17 | 117.50 | 4.17-17.50 |
| Catfish | 102.78 | 122.22 | 2.78-22.22 |

* Percentage increase based on landing prices

Table 3. Price spread between wholesale market and retail market in Veraval

| Variety | Low* | High* | Range of price spread* |
|---|---|---|---|
| Ribbon fish | 105.26 | 200.00 | 5.26-100.00 |
| Croaker | 114.28 | 333.33 | 14.28-33.33 |
| Pony fish | 109.89 | 267.86 | 9.89-167.86 |
| Spotted bearded croaker | 107.59 | 109.76 | 7.59-9.76 |
| Shark | 226.67 | 571.43 | 166.67-471.43 |
| Tuna | 162.16 | 184.21 | 62.16-84.21 |
| Wolf herring | 187.50 | 500.00 | 87.50-400.00 |
| Thread fish | 175.00 | 400.00 | 75.00-300.00 |
| Mackerel | 240.00 | 500.00 | 140.00-400.00 |
| Perch | 200.00 | 476.19 | 100.00-376.19 |
| White pomfret | 104.17 | 150.00 | 4.17-50.00 |
| Seer fish | 120.00 | 187.50 | 20.00-87.50 |
| Catfish | 193.55 | 322.58 | 93.55-222.58 |

* Percentage increase based on wholesale price

Table 4. Price spread between wholesale market and retail market in Cochin

| Variety | Low* | High* | Range of price spread* |
|---|---|---|---|
| Sardine | 214.29 | 606.06 | 114.29-506.06 |
| Mackerel | 208.66 | 818.18 | 108.66-718.18 |
| Seer fish | 410.26 | 521.74 | 310.26-421.74 |
| Pomfret | 727.27 | 848.48 | 627.27-748.48 |
| Threadfin bream | 444.44 | 1509.64 | 344.44-1409.64 |

* Percentage increase based on wholesale price

ies create a large price spread cornering a large share of benefits from the lower prices.

The price spread in the next phase of transaction, i.e., between wholesale market and retail market at Veraval and Cochin is given in Tables 3 and 4, respectively. Price spread at Veraval in the first stage went up to a maximum of 46% (Table 2), whereas the same in the second stage had gone up to 471% (Table 3). While lowest range of price spread in the first stage was within 7%, the corresponding figure in the second stage was 167% in Veraval and 627% in Cochin. At higher levels of price spread, the percentage increase touched peak values of 571% at Veraval and 1410% at Cochin. Assuming that the marketing cost per kg of fish is same, the enormous difference in price spread in the two markets goes to the benefit of marketing intermediaries, particularly the retail vendors. However, it has to be noted that the labour input per unit transaction could be comparatively high which will cut into the marketing margin of the retailers.

The price spread between the wholesale and retail markets discussed above were based on the retail prices of established markets in leading urban and semi-urban centers. However, it has to be mentioned that the profile of retail markets is generally not homogenous. An important link in the marketing chain is the vendor fishermen and fisherwomen who carry the fish to the doorsteps of consumers. As mentioned in the marketing chain flow chart (Fig.1), cycle-borne vendors and vendors on mopeds constitute an important marketing link. Prices of fish from these vendors were found to be 30 to 50% more than the retail prices in the established markets. It was observed that the retail prices charged by the vendors had a high degree of variation from vendor to vendor, particularly with respect to the time of transaction. Prices generally, reach peak values, often 50% above the standard market prices, in the early hours of the day and progressively decline by midday.

The authors are grateful to Director, Central Institute of Fisheries Technology, Cochin for granting permission to publish this paper. The authors also wish to thank Shri K.D. Santhosh and Smt. N.C. Shyla for assistance in data collection and analysis.

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*Book Review*

# Post-harvest Technology of Fish and Fish Products

*By*

**K.K. Balachandran**

*Daya Publishing House, 1123/74, Deva Ram Park, Trinagar*
*New Delhi - 110 035*

*First published : 2001, XI + 440 pp., ISBN 81-7035-237-1, Price : Rs. 895.00*

Processed fish and fishery products constitute the largest single net foreign exchange earner, which brought in more than Rs. 6,400 crores in foreign exchange to the country during 2000-2001. This underscores the importance of post-harvest technology of fish which is now an important academic pursuit of all agricultural as well as regular universities in the country.

In spite of the availability of processable surplus of food materials - grains, fruits and vegetables or animal products including fish - food processing industry in India, perhaps, did not develop to the extent it should have, resulting in avoidable wastage of valuable food materials. This belated realization has resulted in the creation of a separate Ministry of Food Processing in the Union Cabinet. Food processing is today a high tech, state-of-the-art technology and professional study and practical training are essential for its successful application. To derive the beneficial effects of food processing, development of innovative technologies is the most important need. This is particularly so in the case of a highly perishable commodity like fish. However, this aspect received relatively less attention in the matter of meat and fish due to strong vegetarian sentiments among a sizable section of the Indian population. The picture is now changing fast with changes in food habits and increased production and availability of these items in all parts of the country, thanks to the systematic and scientific inputs in the fields of animal husbandry and aquaculture. Several graduate and post-graduate courses in this subject have already been started in almost all the states in the country.

Though fish processing is now an important topic of academic courses, a major problem faced by the students, technologists, researchers and others pursuing it as a profession, is the absence of authentic and comprehensive books dealing with all aspects of this subject. The book under review, authored by Shri. Balachandran, fulfils this long felt need. With his long years of experience and in-depth knowledge in all fields connected with post-harvest technology of fish, he is the ideal person to write such a book and he has done full justice to the subject by his comprehensive coverage of all aspects. This book will be a valuable addition to libraries of all universities, research institutions and fish processing factories. The author and the publisher deserve congratulations and also gratitude of the users for bringing out this book.

The two opening chapters of the book give a brief sum-up of the biochemistry and bacteriology of fish spoilage and preservation which prepares the students to understand the applied aspects dealt with in subsequent chapters. These two chapters are followed by chapters on onboard handling and preservation, drying and dehydration, salting, smoking, marinating, fermented products, battered and breaded products, freeze drying, irradiation, transportation of live

fish, packaging, quality assurance in fishery products and fishery byproducts and waste utilization. The treatment of the subject, as mentioned earlier, is precise, and comprehensive, making it a very valuable publication for students. In a subject that needs multidisciplinary expertise, such an authentic text book covering all aspects in such a comprehensive manner is rare and for the same reason, students are sure to find this book as a great boon.

The graphics, figures, etc., are presented well. Printing, layout and overall presentation are fine, for which the printer and publisher deserve congratulations. For a book of this value, it is reasonably priced also. It is felt that in tune with the current trend on value added products from fish, especially products like ready-to-serve retortable pouch packed preparations, which appear to be the product for the future, this topic could have been presented in a slightly more elaborate way. This can be looked into when a revised edition is brought out. The book is strongly recommended for all libraries.

**K. Devadasan**
*Director*
*Central Institute of Fisheries Technology*
*Cochin - 682 029*

# AUTHOR INDEX

## *Fishery Technology*

2001, Vol. 38 (1 & 2)

*Numbers refer to the first page of the author's article.*


Abdulla, A. 14
Al-Dagal, M.M. 36
Ammu, K. 97
Annamalai, V. 62, 129
Babji, A.S. 14
Balasubramaniam, S. 51
Balasubramanian, A. 77
Basudha, Ch. 110
Bazaraa, W.A. 36
Bihari, B. 51
Bongirwar, D. 8
Boopendranath, M.R. 1
Chakrabarti, R. 18
Chand, B.K. 87
Choudhuri, D.R. 18
Dhevendaran, K. 31
Dora, K.C. 87
George, J.P. 106
Gopal, N. 62, 129
Hameed, M.S. 81
Haniffa, M.A. 115
Huda, N. 14
Jasmine, G.I. 43
Jeyasekaran, G. 28
Joseph, J. 97
Jude, D. 84
Kamat, A. 8
Karunasagar, I. 28
Karunasagar, I. 28
Kathavarayan, E. 77
Kumar, P. 129
Kumaran, M. 125
Kunjipalu, K.K. 1
Manikandavelu, D. 43
Manoharadoss, R.S. 1
Maragal, M.M. 87
Marimuthu, K. 48
Mathai, T.J. 1
Meenakumari, B. 1
Mendon, M.R. 121
Mohan, B. 51
Murthy, H.S. 102, 121
Naik, A.T.R. 102, 121
Nair, D. 106
Nair, N.B. 31
Neethiselvan, N. 43, 77, 84
Ojha, J.S. 59
Ponnusamy, K. 125
Rajakumar, M. 56
Rajashree, R.V. 31
Rajesh, K.M. 121
Ramachandran, A. 22
Remesan, M.P. 129
Salin, K.R. 71
Sankar, T.V. 22
Sarkar, S. 87
Selvaraj, P. 56
Senthilathiban, R. 56
Sethuramalingam, T.A. 115
Shakila, R.J. 92
Shibu, A.V. 81
Sinha, P.M. 59
Sukumaran, N. 48
Thippeswamy, S. 97
Vadhyar, K.J. 71
Vaitheeswaran, T. 84
Vasundhara, T.S. 92
Venkataramani, V.K. 43
Viswanath, W. 110

## SUBJECT INDEX

# *Fishery Technology*

2001, Vol. 38 (1 & 2)

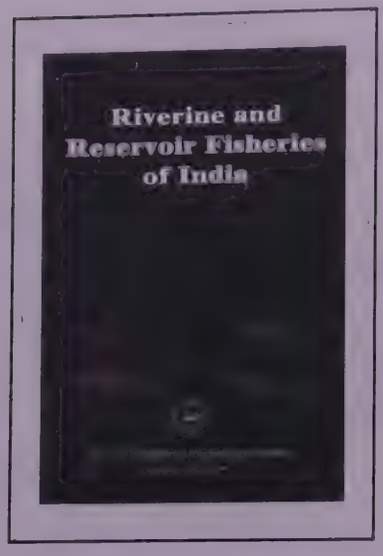
*Page numbers refer to the first page of the paper in which the entry is discussed*


Aeromonas 36
Amino acids 22
Antibiotic susceptibility 36
API-ZYM system 36
Aquaculture 59
Bait 77
Biochemical changes 97
Biochemical characteristics 87
Biogenic amines 92
Canned fish 92
Carp feed 102
Carps 121
Cellulolytic bacteria 31
*Chanos chanos* 97
*Cirrhinus mrigala* 48
Cochin 62
Codend selectivity 1
Cold anaesthetization 71
Catla 22
Comparative efficiency 77
*Cyprinus carpio* 102
Deep frying 87
Dietary energy 115
Dietary protein 115
Economic appraisal 56
*Etroplus suratensis* 43
Extension methods 59
Fatty acids 22
Feed 43
Feed management 106
Fermented ensilage 43
Fish balls 14
Fish consumption 62
Fish drying 97
Fish feed 110
Fishermen 51
Fishing time 81
Folding test 14
Freshwater prawn 121
Fuel consumption 81
Gamma irradiation 8
Gill nets 84
Gillnetter 81
Growth 28, 106, 110
Growth rate 43
Heat penetration 87
Histamine 92
Household income 62
Human resource development 125
Indian major carp 48
*Kowala coval* 28
*Labeo rohita* 115
Landing centre 129
Lipid requirement 48
*Listeria monocytogenes* 8, 28
Live transportation 71
Lobster trap 77
Mackerel 87
Maharashtra 106
Major carps 22
Marketing channel 129
Marketing intermediaries 129
Melanosis 18
Mesh size 84

*Metapenaeus monoceros* 18
Milk fish 97
Mrigal 22
Neutralization 43
Optimum growth 115
Orissa 51
*Osteobrama belangeri* 110
Pelleted feed 121
*Penaeus japonicus* 71
*Penaeus monodon* 106
Polyphenoloxidase 18
Prawn farming 56
Price spread 129
Protein utilization 110
Protein-energy ratio 115
Proximate composition 14
Refrigeration 28
Retail market 129
Rohu 22
Salt dried fish 92
*Sardinella gibbosa* 84
Selectivity 84
Shrimp 71
Shrimp farming 106, 125
Sinking rate 121
Socio-economic status 51
Square mesh 1
Stress care 102
Survival 28, 106
Technology transfer 125
Thanjavur 56
TLC-densitometry 92
Training need assessment 125
Trap design 77
Trawl 1
Vibrio 36
Water quality 106
White sardine 28
Wholesale market 129
*Yersinia enterocolitica* 8

*Book Release Announcement*

# Riverine and Reservoir Fisheries of India




**Edited by Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. & Edwin, L.; First published: 2002, Society of Fisheries Technologists (India), Cochin; pp: xvi + 458; 245x175 mm; hard bound; ISBN: 81-901038-2-2; Price: Rs. 600.00 US$: 40.00**

The new title, *Riverine and Reservoir Fisheries of India*, is based on the Proceedings of *National Seminar on Riverine and Reservoir Fisheries - Challenges and Strategies, 23-24 May 2001, Cochin, India*. The Seminar was jointly organized by Society of Fisheries Technologists (India), Cochin and Central Institute of Fisheries Technology, Cochin, in the context of emerging significance of inland open water fishery resources in the supply of nutritious food and in the economic well-being of the inland fishermen.

The title includes edited versions of 62 papers in areas of Ecology, Resources, Culture and Capture Techniques, Post-harvest Technology and Fisheries Extension and Management. The contents focus on (i) reservoir fisheries development; (ii) ornamental fish culture and export trade; (iii) development of a consensus Code of Conduct for Responsible Fisheries (CCRF) for inland open water resources; (iv) revalidation of inland fishery resource database and development of Geographical Information System on inland water resources as a tool for effective fishery management; (v) conservation and management of inland resources, with accent on long-term sustainability of the fishery resources, protection of biodiversity and environmental safety; (vi) development of efficient post-harvest handling, processing, value addition, quality control, packaging and marketing practices for freshwater fishes; and (vii) extension, training and education in inland fisheries technology.

The contents of this volume provide a new orientation and impetus to inland open water fisheries development and offer better inputs for scientific management and utilization of the resources. A detailed subject index based on key words and species names, author index and table of contents, provided adds to the value of the volume.

> *"This volume addresses the issues, highlights the present constraints in the development and proposes strategies for advancement of riverine and reservoir fisheries..... it will be a useful source of information to planners, scientists, fishery managers, environmentalists and to all those who are directly and indirectly involved in the development, management and responsible utilization of inland open water fishery resources"*
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> - Dr. Panjab Singh, Secretary, DARE & Director General, ICAR, New Delhi.

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Original research and critical review articles on fishery technology and peripheral areas are considered for publication in ***Fishery Technology***. Submission of a manuscript implies that it is not being considered for publication elsewhere. Manuscript in its final form, typed/printed in double space on one side of A4 size bond paper leaving 2.5 cm margin on all four sides, conforming to the general format and style of the journal, should be submitted in ***triplicate*** to the ***Editor, Fishery Technology, Matsyapuri P.O., Cochin - 682 029, India***. Manuscripts may also be submitted as MS-Word or other compatible word processor files on 8.89 cm (1.44 MB) diskettes.

Contributions from authors who are members of the Society of Fisheries Technologists (India) and who do not owe any dues to the Society alone will be considered for publication, except in the case of invited articles.

The papers should be written in clear and concise English, normally in the past tense. All vernacular names, e.g. *'Thoran'*, *'Kattumaram'* must be underlined and briefly described when appearing for the first time. Scientific names must be given in full with authority (*Liza parsia* Hamilton-Buchanan) at the first mention and abbreviated thereafter (*L. parsia*), but must be given in full (without authority) in the headings of sections, tables and figures (*Liza parsia*). SI or Metric Units of measure must be used.

Length of the articles should be limited to 3000 words for reviews, 2000 words for research papers and 1000 words for notes. Papers and notes must consist of the following sections. The **Title** should be brief (6-12 words) and informative followed by a **Running Title** of not more than 60 characters. This should be followed by the **name(s) of the author(s)** with initials and the **name(s) and full address(es)** of the establishment(s) where the work was done. Any change in the address(es) of the author(s) may be indicated as a foot note. Only the above details should appear on the title page.

An **Abstract** of the paper stating the purpose of the work, principal findings and their significance should be provided on a separate page in not more than 150 words. The use of unusual abbreviations or acronyms should be avoided in the abstract.

The **Introduction** should clearly describe the aims of the investigation, scope and rationale of the study. It should include a brief statement of the previous relevant work with references, essential for the reader's orientation. Abstract and Introduction sections should not have headings.

The **Materials and Methods** should be stated clearly so as to permit the work to be repeated. Only new techniques and modifications to known methods need to be elaborated, but even known, standard methods must have full references.

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A **Discussion** of the results and their interpretation should follow the **Results**. A combined **Results & Discussion** section is preferable as it avoids repetition of the results in the latter. **Acknowledgements** must be kept to the minimum and should not have a heading.

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Name and year system is used for citations in the text. One or two authors as Ahmed & Rao (1989) or (Ahmed & Rao, 1989). Three or more authors as Jones *et al.* (1990) or (Jones *et al.*, 1990). Unpublished work should be cited only in the text (Smith, J., unpublished); Menon, A.R., (Pers. comm.). Use subscripts a,b,c etc., (1980a; 1989a,b) to distinguish papers by the same author(s) in the same year. References listed at the end of the paper must be given in the alphabetical order. Papers with three or more authors should be listed chronologically after any other paper(s) by the first two authors. Title of the journals should be abbreviated in accordance with the World List of Scientific Periodicals (4th edition and supplements). Note the following order and styles for various literary sources.

**(a)** Published papers/notes/reviews

Jambunathan, R., Sridhar, R., Raghunath, K., Dwivedi, S.L. & Nigam, S.N. (1993) *J. Sci. Food Agric.* **61**, 23

**(b)** Books/approved methods

i) Brandt, A.V. (1984) *Fish Catching Methods of the World*, 3rd edn., p. 253, Fishing News Books, Farnham, UK

ii) AOAC (1984) *Official Methods of Analysis*, 14th edn., Association of Official Analytical Chemists, Washington, DC, USA

**(c)** Chapters in edited books/papers in symposium proceedings

i) Steinberg, R. (1971) in *Modern Fishing Gear of the World* Vol. 3 (Kristjonsson, H., Ed.), p. 423, Fishing News (Books) Ltd., London, UK

ii) Solanki, K.K. & Sankar, T.V. (1987) in *Proceedings of 1st Indian Fisheries Forum*, p. 391, Mangalore, India

**(d)** Reports by specified authors/Institutions

i) Daget, J. (1964) *Application of Food Irradiation in Developing Countries*, p. 73, Panel report No. 54, IAEA, Vienna, Austria

ii) BIS (1971) *Methods of test for fishing gear materials* IS 5815 (Part II), Bureau of Indian Standards, New Delhi, India

iii) FAO/WHO (1973) *Energy and Protein Requirements*, Report of FAO Nutritional Meeting Series No. 52, FAO, Rome, Italy

**(e)** Patents

Adler-Nissen, J. (1978) *Enzymatic modification of corn gluten*, US Patent 4100151

**(f)** Thesis

Mahesh, T. (1986) *Preparation of Functional Fish Protein Concentrate,* M.F.Sc. Thesis, Univ. Agri. Sci., Bangalore, India

**(g)** Papers presented at Symposia/Conference

Rajyasree M. & Neeraja, P., (1993) Paper 48 presented at the Int. Symp. on Nutrients and Bioactive Substances in Aquatic Organisms (SOFT (I) & CIFT) Cochin, India, 14-17 Sept.

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